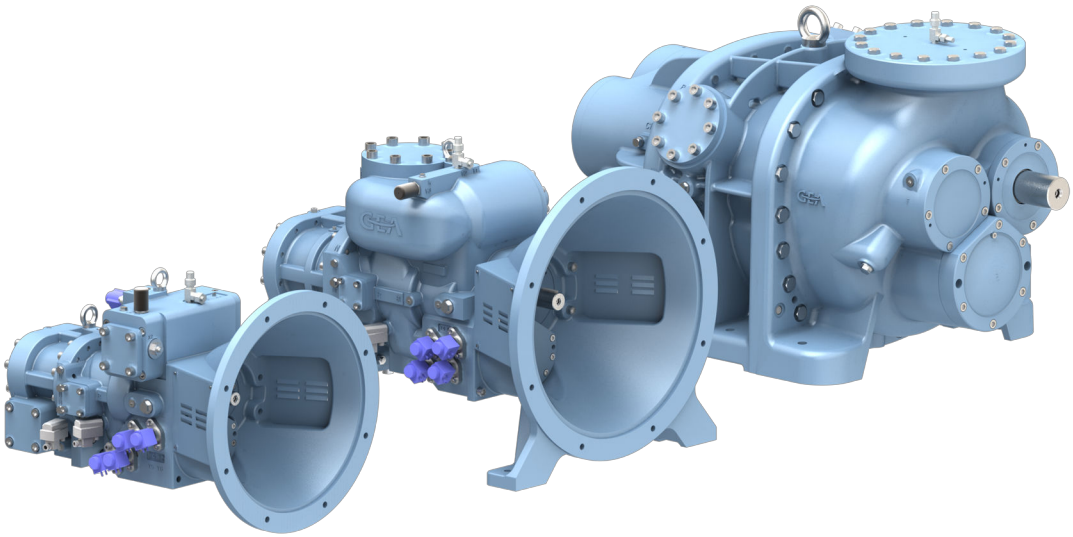


GEA Screw compressor

Frame size C ... XH

Product Information (Translation from the original language)

C_101011_19

engineering for a better world

gea.com

SYMBOLS USED

⚠ Danger

Stands for an immediate danger leading to severe physical injuries or death.

► Description for avoiding the danger.

⚠ Warning!

Stands for a potentially dangerous situation leading to severe physical injuries or death.

► Description for avoiding the dangerous situation.

⚠ Caution!

Stands for a potentially dangerous situation which could lead to minor physical injuries or damage to property.

► Description for avoiding the dangerous situation.

Notice

Stands for important information that must be observed for the intended use and function of the product.

► Description of the required action for the intended function of the product.

TABLE OF CONTENTS

1 INTRODUCTION

This product information specifically describes screw compressors used in the refrigeration, air conditioning and heat pump technology.

For product information for other applications please contact GEA Refrigeration Germany GmbH.

1.1 Area of application

The screw compressors are oil-injected twin shaft rotary positive displacement machines that work according to the displacement principle.

The machines are available as standard refrigeration compressors for single-stage operation, as boosters as well as heat pump compressors and compressors for process gas, natural gas, or helium compression.

The compressors can be used, for example, in cold storage houses, in the food industry (slaughter houses, breweries, dairies, fruit and vegetable processing), air conditioning, chemical and petrochemical industries, refrigerating, cooling and air conditioning plants on ships as well as for heat pump operation.

The refrigerants NH_3, R744 (CO_2), R290 (propane), R1270 (propene), R22, R23, R134a, R404A, R407C, R410A, R507 and other refrigerants and refrigerant mixtures can be used, depending on the compressor frame size, up to a maximum operating pressure of 52 bar.

For these refrigerants, refrigerator oils are to be chosen in accordance with the information on lubricating oils for screw compressors (Chapter 11, Page 198).

The compressors are generally run directly with an electric motor via a flexible coupling. Based on the frame size, they are suitable for speeds between 1000 rpm and 6000 rpm. The compressors may also have combustion or gas engines as drives.

1.2 Product range

The Grasso screw compressor product range currently consists of 24 frame sizes, which are assigned to the M series and the LT series. With the compressors of these frame sizes, suction volume flows from 231 to 11467 m³/h (at 2940 rpm) can be achieved. Compressors of the same size can have varying suction volumes thanks to a special interior design. The classification of the compressor sizes and suction volumes can be found based on type descriptions in the (Chapter 3, Page 12) data sheet.

Series M, frame sizes C, D, E, G, H, L, M and N.

The LT series includes the frame sizes: P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG and XH.

The series differ from each other in the level of integration of functional components of the oil and refrigerant circuits.

The compact screw compressors in the **M** (Medium) series have a suction-side check valve, suction filter and integrated solenoid valves for capacity control and adjusting the inner volume ratio (Vi). The oil for function and injection oil can be supplied centrally or separately. For compressors of frame sizes C, D, E and G, an optional oil filter can be integrated. The compressors are offered with a coupling and coupling housing, so that a drive motor with flange can be mounted directly. Optionally, these compressors can also be installed individually by the drive motor.

Screw compressors in the LT series have an integrated solenoid valve combination for capacity control and adjusting the inner volume ratio (Vi). Screw compressors in the LT series need external filters and valves as well as compartmentalized oil intake systems.

The screw compressors have an infinitely adjustable capacity control and may be equipped with self-regulating, alterable inner volume ratio (Vi) (tandem slide, TS system). Compressors with set installed volume ratios Vi are available in sizes of 1.8 to 5.5 depending on the compressor size. The Vi value in compressor selection program is calculated for the specific usage. The specific design and the necessary equipment of the compressor are specified during order processing.

All compressors are equipped with one or two economiser connections and have connections for refrigerant injection as well as for returning oil from the plant system. Compressors for high pressure conditions are equipped for self-controlling systems with low pulse operation in the lower partial load range.

All compressors have prepared mating surfaces to install sensors for vibration measurement. The LT series compressors may also be equipped with sensors for monitoring bearing temperatures as well as monitoring of the axial rotor position. The M series compressors can be equipped if needed, taking into account the frame size, with sensors for monitoring the axial rotor position.

Grasso screw compressors are characterized amongst other by a compact design, by their reliability, by the application of high quality components and by its maintainability.

Before delivery, each compressor is subjected to a test run with nitrogen in the pressure range of the future application which is proven by a works test certificate accompanying each compressor. Test runs with ammonia can be carried out optionally, at a corresponding additional cost. On request, a certificate of acknowledged classification societies, e.g. TÜV, Lloyds Register of Shipping, Germanischer Lloyd, Norske Veritas, Bureau Veritas, will be provided.

The solenoid valve and position sensors for capacity controls and Vi adjustment may be delivered with UL/CSA certification.

The compressors are available in explosion-proof execution.

A comprehensive quality assurance system based on DIN ISO 9001 and comprising all stages from design/ development, manufacturing, assembly and testing through to customer service guarantees an excellent quality of the Grasso Screw compressors.

The compressors are delivered without oil.

All connections are sealed and the compressors are filled with dry nitrogen (0.5 bar gage pressure). Every compressor comes with an Installation and Maintenance Manual and safety instructions, information on the working principles and installation, maintenance and repairs as well as on the tools and spare parts.

1.3 Technical features

Rotors

The rotors are made from machined or forged tool steel. They are designed according to the criteria of low energy consumption and high efficiency (patented profile). The male rotor is driven by the motor, whereas the female rotor is directly driven by the male rotor by means of a thin oil film.

The end of the drive shaft has a cylindrical outer contour and may be designed with or without feather key, depending on the frame size. On a compressor design in accordance with ATEX guidelines, the end of the drive shaft has a cylindrical outer contour with a feather key.

Housing

The housings for operating pressures up to 28 bar are made of laminar grey cast iron. The housings for operating pressures up to 52 bar and higher are made of spheroidal cast iron. Compressors with special requirements in accordance with API 619 are available with a cast steel housing.

Bearings

The compressors of the M series are completely equipped with roller bearings. High-performance cylindrical roller bearings for absorbing radial forces and angular contact ball bearings for absorbing axial forces provide for a theoretical life of up to 100,000 operating hours. On compressors from the LT series, low-wear radial bearings absorb the radial forces of the rotor shafts and angular contact ball bearings through a thin oil film. A hydraulically-loaded balance piston reduces the axial force acting on the axial bearings and increases their lifespan.

Shaft seal

The oil-blocking shaft seal with a rotating and a fixed ring is responsible for sealing off the driven male rotor shaft to the atmosphere. Depending on the anticipated wear on the shaft seal, various material pairings can be used. The seal designed to relieve loads and the thin oil film between the rings ensure a long service life. For special applications the compressors can be equipped with a double-action shaft seal.

Capacity control

Through an infinitely variable control slide with an hydraulic mechanism, the suctioned swept volume can be adjusted between 100% and a minimum value. Compressors with a variable volume ratio operate according to a system of combined Vi partial-load control.

Position indication

For position indication of the hydraulic systems of the capacity control and the Vi adjustment, a hermetic position sensor is used that provides an output signal between 4 and 20 mA.

For a compressor design in accordance with the ATEX directive, a displacement sensor with degree of protection ⟨Ex⟩ II 2G Ex ib IIC T5/T6 Gb is used. This must be used together with the Zener barrier specified by the sensor manufacturer.

For screw compressors that operate in the parallel connection with additional compressors and have a check valve installed, the adjustment path for the control slide in the capacity control must be limited through parameters in the compressor control system with a minimum control slide setting while the compressor is operating. The minimum control slide position limits the MIN position of the slide and ensures a minimum flow rate for the compressor.

Optional equipment specifications

In addition to the specifications listed above, the compressors can optionally also be equipped with other components.

- Double-acting shaft seal.
- Axial plain bearing.
- Bearing temperature monitoring for the radial bearings.
- Rotor positioning system for monitoring the axial position of the rotors.

2 PRODUCT OVERVIEW

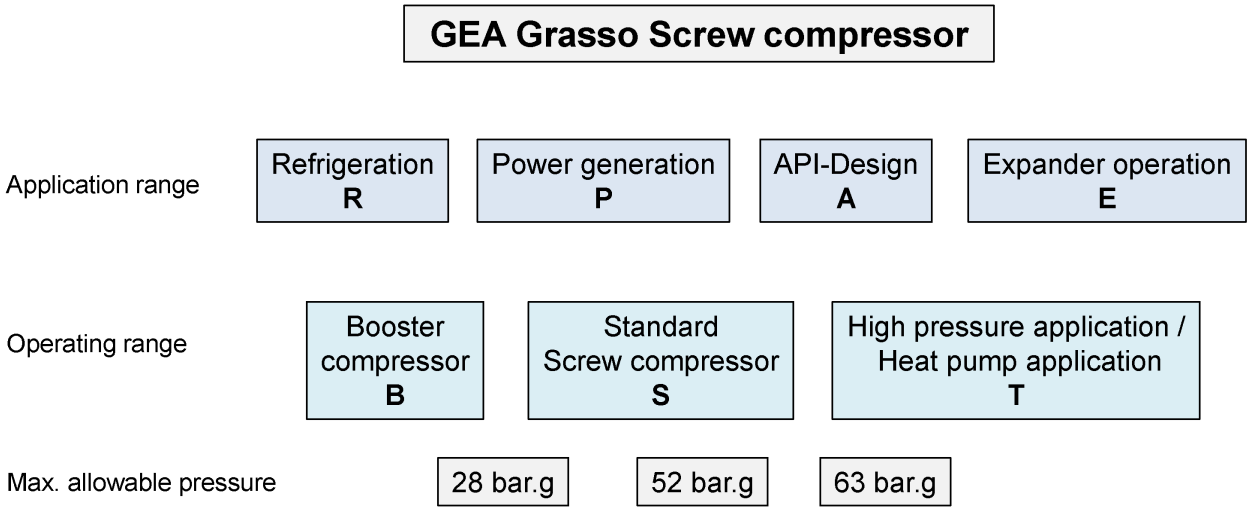


Fig.1: Product Overview / Fields of Applications
Compressors with a maximum permissible pressure of 63 bar are available for selected sizes

Notice

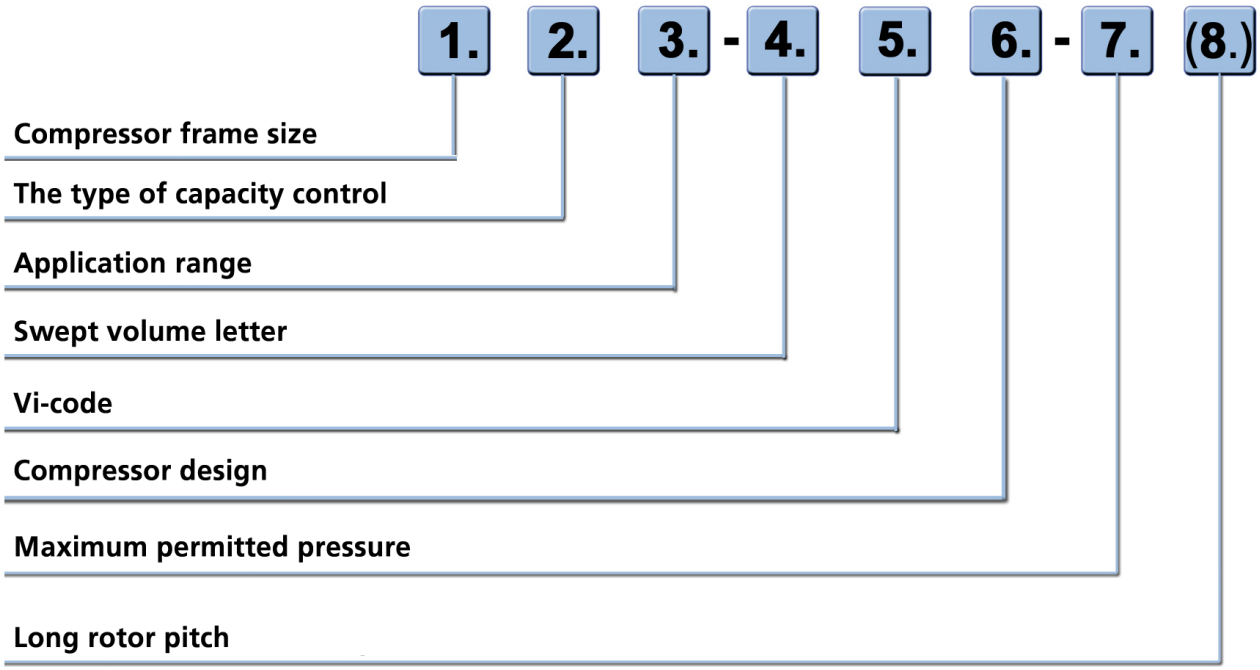
Note!

► For model designation please refer to Chapter 3, Page 12.

3 COMPRESSOR DESCRIPTION

3.1 Product designation, screw compressor

GEA Grasso M and GEA Grasso LT series



Product code description

Code	Description
1.	Compressor frame size
2.	The type of capacity control [1]
3.	Application range
4.	Swept volume letter
5.	Vi-code
6.	Compressor design
7.	Maximum permitted pressure
(8.)	Long rotor pitch

1. Compressor frame size

The 24 available compressor frame sizes are described by the following letters.

Series	Compressor frame size								
M	**C**	**D**	**E**	**G**					
	H	**L**	**M**	**N**					
LT	**P**	**R**	**S**	**T**	**V**	**W**	**Y**	**Z**	**XA**
	XB	**XC**	**XD**	**XE**	**XF**	**XG**	**XH**		

1 applies only for compressors of the GEA Grasso M series

2. Type of capacity control

(hereinafter called “Style”)

Code	Description
S	"**S**"peed controlled capacity, The compressor is driven by a variable speed drive. The capacity is controlled by the speed of the drive machine. The compressor is equipped with variable Vi and is only equipped with on Vi-slider.
M	"**M**"echanical capacity control, The compressor usually runs at constant speed. The capacity control is carried out via a mechanical slide control. The compressor can be equipped with a fixed or variable Vi

3. Application range

Code	Description	
R	Cold, air-conditioning-, heat pump technology	"**R**efrigeration"
P	Power generation	"**P**ower Generation"
A	API 619-Requirements	"**A**PI 619 Standard"
E	Expander operation (energy recovery)	"**E**xpander Operation" (energy recovery)

4. Swept volume letter

The swept volume letter describes the theoretical swept volume flow of the compressor and will be described with letters. The letters are identical to the letters of the compressor frame sizes.

The compressor frame size letter and the swept volume letter are the same in standard versions.

If not, the particular frame size has a reduced suction volume flow. This is a special compressor design and considered a "heavy duty version".

Swept volume letter	Suction volume flow in m³/h [2]		Swept volume letter	Suction volume flow in m³/h [2]
C	231		P	805
D	265		R	1040
E	321		S	1290
G	372		T	1460
H	471		V	1740
L	544		W	1990
M	708		Y	2390
N	870		Z	2748
			XA	3250
			XB	4150
			XC	4900
			XD	5800
			XE	7170
			XF	8560
			XG	9807
			XH	11467

2 at 2940 rpm (50 Hz power system); for 60 Hz power system multiply by 1,2.

5. Vi-code

The Vi code describes the inner volume ratio of the screw compressor.

Code	Vi fixed - Standard codes, all series							
Vi	1.8	2.0	2.2	2.6	3.0	3.6	4.8	5.5
Code	18	20	22	26	30	36	48	55

Vi variable - Standard codes, GEA Grasso M series

Series	M				
Design	M			S	
Vi	1.8...3.0	2.2...4.0	2.6...5.5	1.4...2.7	1.8...5.0
Code	1830	2240	2655	1427	1850

Vi variable - Standard codes, GEA Grasso LT series

Series	LT					
Frame size	P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF			XG, XH		
Vi	1.8...3.0	2.2...4.0	2.6...5.5	1.8...2.8	2.2...3.8	2.6...5.2
Code	1830	2240	2655	1828	2238	2652

6. Compressor design

Code	Description
A	Thrust bearing in sleeve bearing design, standard balance piston.
B	Booster: Standard-thrust bearing design, MR + FR, without balance piston.
C	Standard-thrust bearing design, MR + FR, with smaller balance piston.
D	Thrust bearing in Triax design, MR, with smaller balance piston.
E	Thrust bearing in Triax design, MR, without balance piston.
H	Thrust bearing in Triax design, MR + FR, Standard balance piston.
J	Thrust bearing in Triax design, MR + FR, with smaller balance piston.
K	Thrust bearing in sleeve bearing design, with smaller balance piston.
R	Thrust bearing in Tandem design MR, standard balance piston.
S	Standard-thrust bearing design, MR + FR, standard balance piston.
T	Thrust bearing in Triax design, MR, standard balance piston.
V	**v**ariable capacity control with speed-control, **v**ariable Vi with Vi-slide control, no control slide. Thrust bearing in Tandem design, MR.

7. maximum permitted pressure (gauge pressure)

The maximum permissible pressure is based on DIN EN 378-1 and describes the limits for operating pressure, which may not be exceeded at the compressor during operations or after shut down of the plant. In addition to the stability of the casing parts, the maximum permissible loads on the drive shafts and bearings shall also be taken into account, which then result in the operating conditions for the compressor (suction pressure, discharge pressure). The maximum permissible pressure is marked on the type plate of the compressor.

The compressors are available in standard design types for three maximum allowable pressures:

- 28 bar
- 52 bar

- 63 bar, available for selected frame sizes

Deviating from the standard, a different maximum permissible pressure can be agreed depending on the application.

8. Long rotor pitch

The use of a long rotor slope enables the operational area to be expanded by individual compressors.

Only the compressors with a “long slope” are labelled with an additional letter.

Summary of nomenclature:								
	1.	2.	3.	4.	5.	6.	7.	8.
Variable values	C, D, E, G H, L, M, N P, R, S, T V, W, Y, Z, XA XB, XC, XD XE, XF	S, M	A E P R	C, D, E, G H, L, M, N P, R, S, T V, W, Y, Z, XA XB, XC, XD XE, XF	18, 20 22, 26, 30 36, 48, 55 1427, 1850 2640, 3248, 2648 1830, 2240, 2655	A B C D E H J K R S T V	28 52 63	(L)
	XG, XH			XG, XH	18, 20 22, 26, 30 36, 48, 55 1828, 2238, 2652		28	

4 COMPRESSOR DESIGN CRITERIA

Compressor Frame size	Theoretical suction volume flow [m^3/h] (0)	ZM/ZF (1)	Vi adjustment (2)	Compressor-equipment (3)	Bearing radial/axial (4)	Oil supply (5)	Drive-motor (6)
C	231	5/6	TS ES	B, C	W/W	M/N	F/E
D	265	5/6	TS ES	B, C	W/W	M/N	F/E
E	321	5/6	TS ES	B, C	W/W	M/N	F/E
G	372	5/6	TS ES	B, C	W/W	M/N	F/E
H	471	5/6	TS ES	B, C	W/W	M/N	F/E
L	544	5/6	TS ES	B, C	W/W	M/N	F/E
M	708	5/6	TS ES	B, C	W/W	M/N	F/E
N	870	5/6	TS ES	B, C	W/W	M/N	F/E
P	805	5/6	TS	A; B	G/W	M	E
R	1040	5/6	TS	A; B	G/W	M	E
S	1290	5/6	TS	A; B	G/W	M	E
T	1460	5/6	TS	A; B	G/W	M	E
V	1740	5/6	TS	A; B	G/W	M	E
W	1990	5/6	TS	A; B	G/W	M	E
Y	2390	5/6	TS	A; B	G/W	M	E
Z	2748	5/6	TS	A; B	G/W	M	E
XA	3250	5/6	TS	A; B	G/W	M	E
XB	4150	5/6	TS	A; B	G/W	M	E
XC	4900	5/6	TS	A; B	G/W	M	E
XD	5800	5/6	TS	A; B	G/W	M	E
XE	7170	5/6	TS	A; B	G/W	M	E
XF	8560	5/6	TS	A; B	G/W	M	E
XG	9807	5/6	TS	A; B	G/W	M	E
XH	11467	5/6	TS	A; B	G/W	M	E

(0)		at 2940 rpm (50Hz power system); for a 60Hz power system, multiply values by 1.2. The values of the swept volume flow refer to the standard design of the compressor, when the frame size and the swept volume have the identical letter (see data sheet model designation Chapter 3, Page 12)
(1)	ZM	numbers of lobes, male rotor
	ZF	numbers of lobes, female rotor
(2)	TS	tandem slide system TS : infinitely variable Vi adjustment
	ES	single slide ES : infinitely variable Vi adjustment
(3)	A	standard configuration with solenoid valve blocks for capacity and Vi-adjustment of the compressor;
	B	special design without solenoid valves / solenoid valve blocks;

	C	flanged solenoid valves for capacity and Vi-adjustment on the compressor, suction filter*), check valve suction side*), oilfilter*) (only frame sizes C, D, E, G)
(4)	W	Roller bearings
	G	Sleeve bearings
(5)	M	compressor operation with external oil pump
	N	compressor operates without oil pump
(6)	F	flange motor
	E	motor and compressor installed separately
		with *) labeled components are optional.

5 OPERATING LIMITS

The screw compressors can be operated under the very different operating conditions within the given operating limits, depending on the applicable requirements. The operation limits listed below are based on thermodynamic ratios and are based on operating conditions and compressor design. The tabulated data apply for single-, two-stage and heat pump operation. Depending on the specific operating conditions, the compressor the manufacturer selected may cause restrictions to the limit values specified in the table.

Notice

Hint for compressor selection!

► For specific operations the selection and evaluation will takes place in the manufacturer's compressor selection program **"RTSelect"**.

⚠ Caution!

Compressor damage warning!

► To avoid "zero flow" in the compressor, which can damage the compressor, the minimum controlling slide position in the manufacturer's compressor selection programm **"RTSelect"** must be adhered to. **"Minimal control slide position <value>% except start."**

► In case the calculated value is **"> 0"**, a limitation of the control slide path has to be done by consultation the manufacturer to prevent a zero-flow operation of the compressor. The path limitation can be set virtually using the compressor control (“virtual stop sleeve”).

Permissible pressure (EN 378) (Gauge pressure)	p	max.	≤28 bar or ≤52 bar
Pressure ratio (p_c/p_0)	π	min.	>1.5
		max.	< 22
Pressure difference (p_c - p_0)	Δp	min.	> 0.8 bar
Suction temperature [3]	t_{0h}	min.	≥ - 60°C
Discharge temperature (compressor outlet)	t_e	max.	≤ 120°C

3 A dry-saturated steam has to be ensured during the suction process (no liquid).

Compressor frame size		C/D	E/G *)		H/L	M/N *)	
			28 bar	52 bar		28 bar	52 bar
max. Drive power (kW) at	3000 rpm	150	150	220	300	300	530
	3600 rpm	180	180	265	360	360	640
max. Nominal torque **)	Nm	500	500	710	960	960	1700
max. Permissible speeds	rpm	6000	6000	6000	4500	4500	4500
min. Permissible speed	rpm	1000	1000	1000	1000	1000	1000

Compressor frame size		P	R/ S/ T	V/ W /Y	Z/ XA	XB/ XC/ XD	XE/ XF	XG/ XH
max. Drive power (kW) at	3000 rpm	530	530	1250	1250	1800	3280	3472
	3600 rpm	640	640	1500	1500	2160	3940	4193
	4500 rpm	-	800	-	-	-	-	-
max. Nominal torque **)	Nm	1700	1700	4000	4000	5750	10440	11278
max. Permissible speeds	rpm	3600	4500	3600	3600	3600	3600	3600
min. Permissible speed	rpm	1500	1500	1500	1500	1500	1500	1500

*) In the size E/G and M/N the compressors have different drive shaft ends.

**) When running the compressor the maximum torque falls by 25% as opposed to electrical drives.

The indicated max. permissible driving power are upper limits determined by the drive shaft ends. The review will be carried out in the compressor selection program.

Notice

Practical tip!

► **All requirements in chapters “Operating limits”, “Installation” and following requirements must be fulfilled to guarantee a save operation of the compressor.**

► Compressors for a discharge pressure up to 52 bar, 52 bar are equipped with housings made of a material of higher strength and are fitted with special components.

► Minimum suction overheating in compressor inlet: "wet" operation has to be avoided.

► For $\Delta p = p - p_o \leq 2.9$ bar an external oil pump to be taken for frame sizes C to N.

► For $\Delta p = p - p_o \leq 4$ bar for compressors of LT series with Vi-adjustment, a functional oil pressure of $p_{oil} \geq p_0 + 4{,}5$ bar needs to be guaranteed.

► For $\pi \geq 8$ gas vibration protection is required.

► For the use of CO_2 in the compressors of all types, depending on the operating conditions it has to be verified the use of a full-flow oil pump for injection oil and functional oil; for types Z to XH, depending on the operating conditions it has to be verified the use of a full-flow oil pump or a partial-flow oil pump for functional oil.

► The discharge temperature t_e must be 10 K above the condensing temperature ($t_e \geq t_c$ + 10 K).

► Due to the solubility of refrigerant in the oil following applies:

- for Ammonia:
  - **$t_e \geq t_{oil}$ + 5 K**;
  - **$t_e \geq t_{oil}$ + 10 K**, when using a PAG oil (dissolving of refrigerant in the oil).
- For R22, R134a, R404A, R407C, R410A, R507, CO_2, natural gas, hydrocarbon compounds:
  - **$t_e \geq t_{oil}$ + 10 K**, when refrigerant is dissolved in the oil.

→ **To determine the permitted difference between the discharge temperature (t_e) and oil intake temperature (t_{oil}) the set viscosity and the solubility diagram for the refrigerant-oil pair from the lubrication supplier need to be adhered to.**

► Ensure that the oil viscosity is 7...70 cSt for the oil supply to the bearings (frame sizes XG, XH: ≥15...70 cSt). Take into account the drop in viscosity due to refrigerant dissolved in the oil!

► Limits for temperature differences will be considered in compressor selection programs.

► The oil temperature at the compressor inlet must be at least 18°C, the oil must be preheated if necessary.

► The rate of temperature change at compressor suction side should not exceed 0,1 K/s.

► Rotation direction: view to compressor’s driving shaft, clockwise.

► For individual cases outside the permitted speed coordination needs to made with the manufacturer.

p_c	Discharge pressure / condensing pressure	t_{0h}	Suction temperature (compressor inlet)
p_0	Suction pressure	t_e	Discharge temperature (compressor outlet)

Δp	Pressure difference (p_c - p_0)	t_c	Condensing temperature
π	Pressure ratio (p_c/p_0)	t_{oil}	oil inlet temperature into the compressor

Notes:

1. During tests of a certain application case, all the conditions specified in the table must be considered and adhered to.
2. Should the given limits not be adhered to in individual cases, the manufacturer needs to be consulted.
3. In addition to the operating limits stated in the tables, the applicable operating conditions of the compressor type in question must also be considered (e.g. g. start-up regime, oil pressure, oil quantity, etc.).
4. Depending on the refrigeration requirements, economiser operation takes place at a control slide position between 100% and approx. 70%.
5. If **R134a** is used as a refrigerant with **condensation temperature of > 60 °C** the manufacturer needs to be contacted.

6 M series; frame sizes C, D, E, G

6.1 Nominal data; frame sizes C, D, E, G

Nominal data; frame sizes C, D, E, G; 28 bar									
		Compressor frame size							
		C		D		E		G	
		Design M	Design S	Design M	Design S	Design M	Design S	Design M	Design S
Intake volume flow at 2940 min^{-1}	[m^3/h]	231		265		321		372	
Number of teeth rotors MR / FR	[-]	5 / 6							
Speed, max	[rpm]	6000							
Speed, min	[rpm]	1000							
Range of the capacity control, stepless		10% * ... 100 %							
Max. Driving power at 50Hz / 60Hz	[kW]	150 / 180							
Max. Nominal torque	[Nm]	500							
Vi variable		1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0	1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0	1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0	1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0
Vi = fixed		1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-	1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-	1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-	1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-
Mass moment of inertia of the rotor pair	[kgm^2]	0.0325		0.0385		0.0618		0.0716	
Weight without motor with / without coupling housing	[kg]	392 / 292		401 / 301		444 / 344		451 / 351	

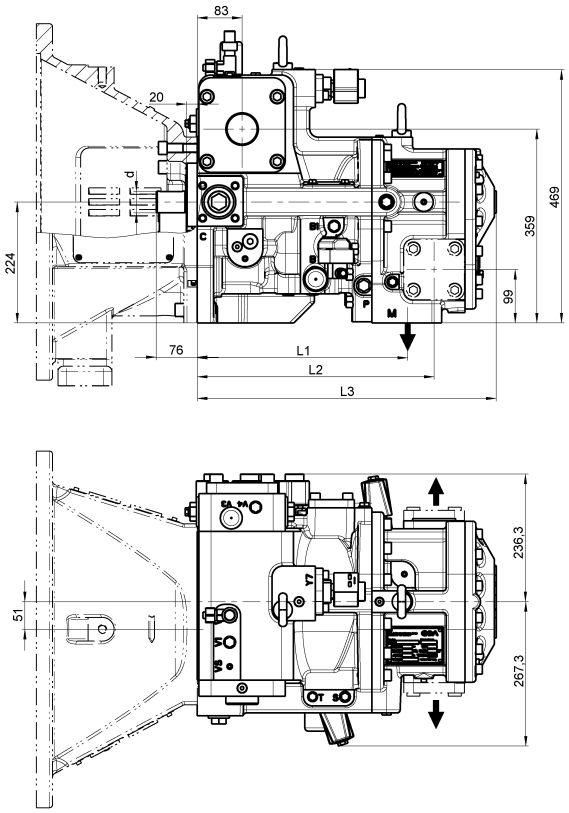
* This value may vary depending on the operating conditions.

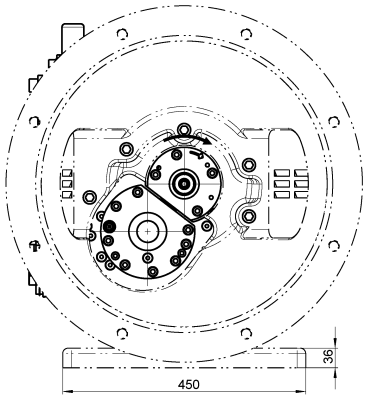
Nominal data; frame sizes E, G; 52 bar					
		Compressor frame size			
		E			**G**
		Design M			**Design M**
		Swept volume letter			**Swept volume letter**
		C	**D**	**E**	**G**
Intake volume flow at 2940 min^{-1}	[m^3/h]	231	265	321	372
Number of teeth rotors MR / FR	[-]	5 / 6			
Speed, max	[rpm]	6000			
Speed, min	[rpm]	1000			
Range of the capacity control, stepless		10% * ... 100 %			
Max. Driving power at 50Hz / 60Hz	[kW]	150 / 180			
Max. Nominal torque	[Nm]	710			
Vi variable		1.8...3.0 2.2...4.0 2.6...5.5			1.8...3.0 2.2...4.0 2.6...5.5
Vi = fixed		1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5			1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5
Mass moment of inertia of the rotor pair	[kgm^2]	0.0469	0.0529	0.0618	0.0716
Weight without motor with / without coupling housing	[kg]	444 / 344			451 / 351

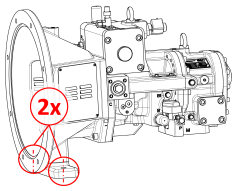
* This value may vary depending on the operating conditions.

6.2 Main dimensions; frame sizes C, D, E, G

Frame Sizes C, D
Single settings with coupling housing; mounting plate







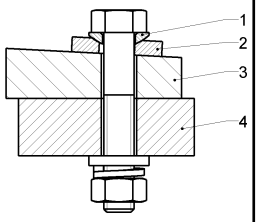
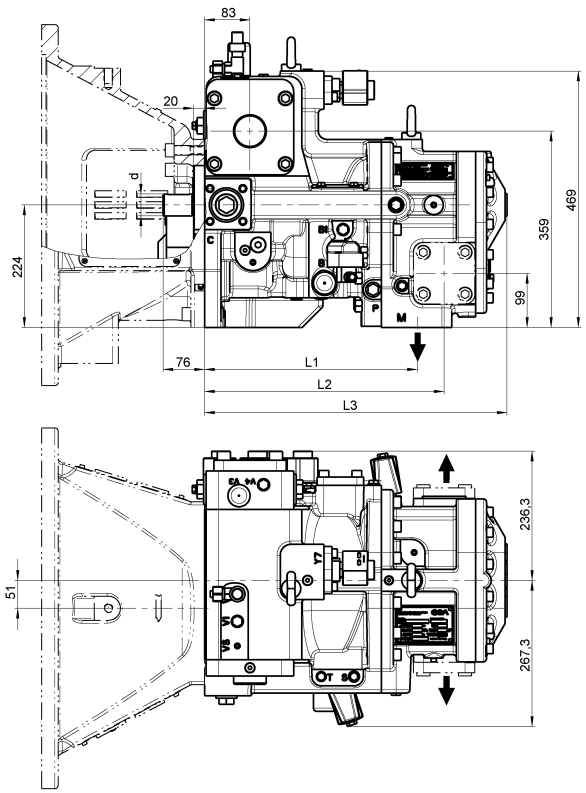


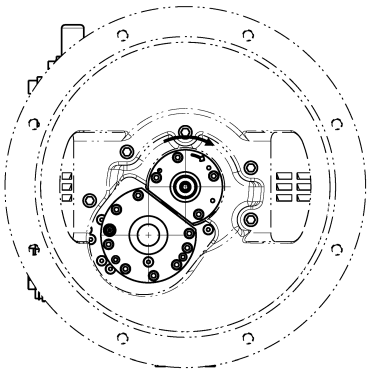
Fig.2

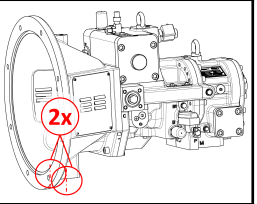
1	Spherical washer
2	Conical seal
3	Coupling housing
4	Screw Compressor Package

Main dimensions, connection dimensions Single settings with coupling housing; mounting plate			
Main dimensions		**Compressor <u>without</u> coupling housing and coupling**	
		Frame size C	**Frame size D**
l1 [mm]		389.5	419.5
l2 [mm]		438.5	468.5
l3 [mm]		553.5	583.5
Drive shaft diameter d [mm]		40 h6	40 h6
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 65	DN 65
	Economizer	DN 40	DN 40
approx. Weight (kg) with/without Coupling housing		392 / 292	401 / 301
For the dimensions of the coupling housing see Section 6.3, Page 32 and the following:			

Frame Sizes C, D
Single settings with coupling housing; direct fixing







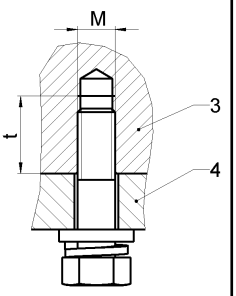


Fig.3

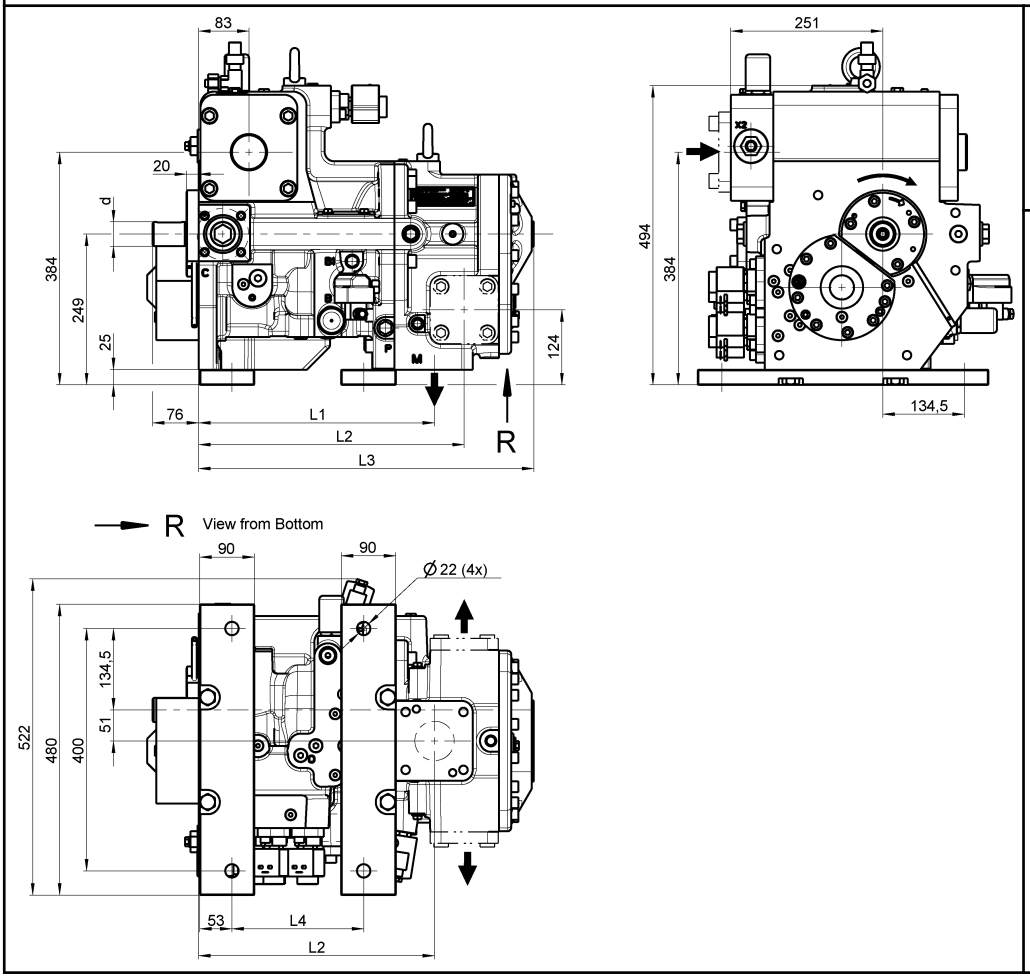
3	Coupling housing
4	Screw Compressor Package
M	M20
t	35 mm

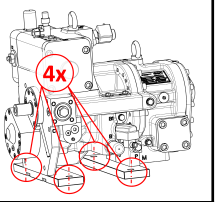
Main dimensions, connection dimensions
Single settings with coupling housing; direct fixing

Main dimensions		Compressor <u>without</u> coupling housing and coupling	
		Frame size C	**Frame size D**
l1 [mm]		389.5	419.5
l2 [mm]		438.5	468.5
l3 [mm]		553.5	583.5
Drive shaft diameter d [mm]		40 h6	40 h6
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 65	DN 65
	Economizer	DN 40	DN 40
approx. Weight (kg) with/without Coupling housing		392 / 292	401 / 301

For the dimensions of the coupling housing see Section 6.3, Page 32 and the following:

Frame Sizes C, D
Single settings with mounting plate





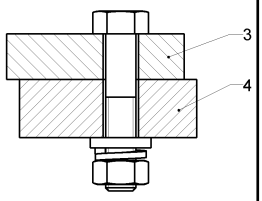
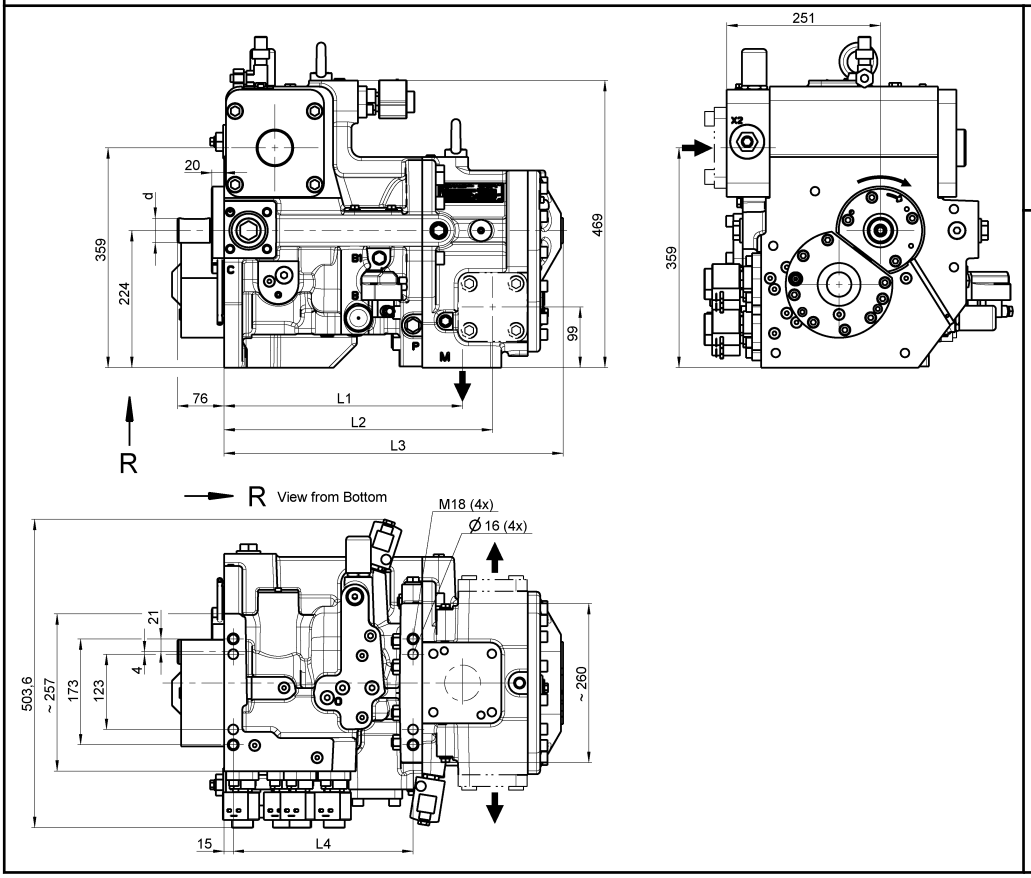


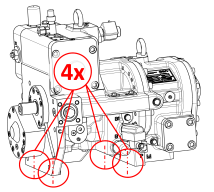
Fig.4

3	Mounting plate
4	Screw Compressor Package

Main dimensions, connection dimensions Single settings with mounting plate			
Main dimensions		**Compressor**	
		Frame size C	**Frame size D**
l1 [mm]		389.5	419.5
l2 [mm]		438.5	468.5
l3 [mm]		553.5	583.5
l4 [mm]		217.5	247.5
Drive shaft diameter d [mm]		40 h6	40 h6
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 65	DN 65
	Economizer	DN 40	DN 40
approx. Weight (kg)		292	301

Frame Sizes C, D
Single setting





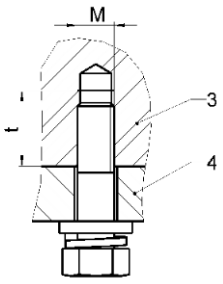
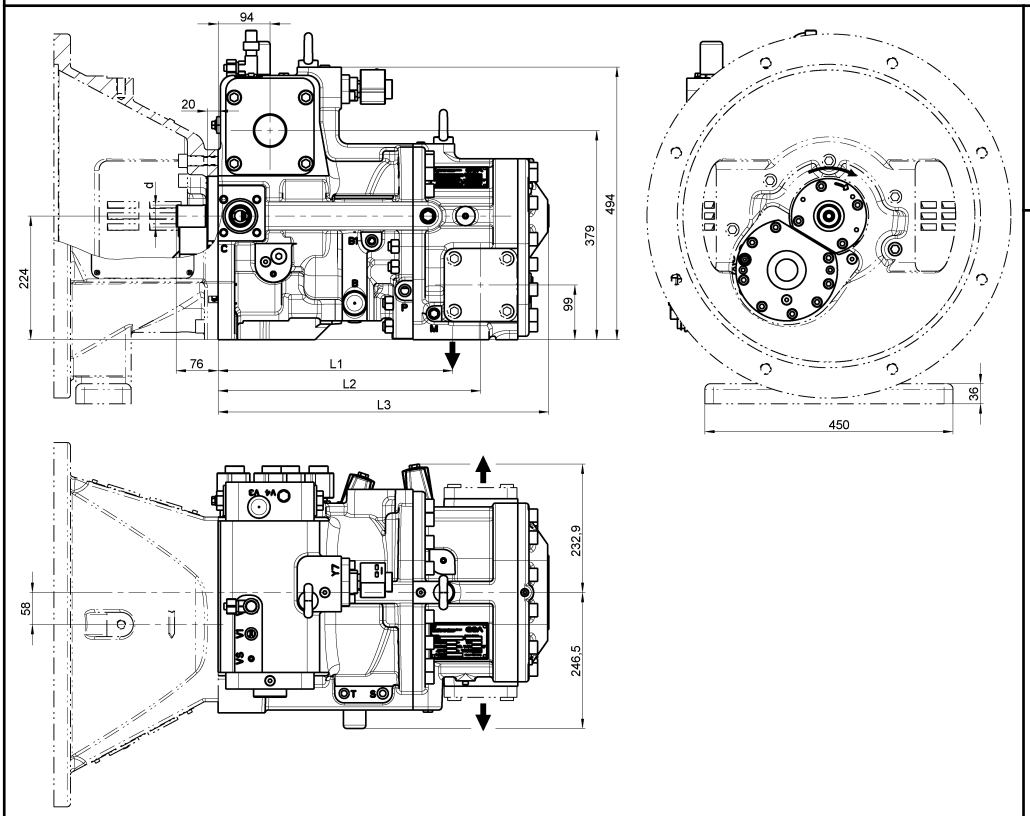


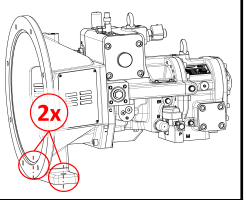
Fig.5

3	Compressor
4	Screw Compressor Package
M	M16
t	34 mm

Main dimensions, connection dimensions Single setting			
Main dimensions		**Compressor**	
		Frame size C	**Frame size D**
l1 [mm]		389.5	419.5
l2 [mm]		438.5	468.5
l3 [mm]		553.5	583.5
l4 [mm]		293.5	323.5
Drive shaft diameter d [mm]		40 h6	40 h6
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 65	DN 65
	Economizer	DN 40	DN 40
approx. Weight (kg)		292	301

Frame Sizes E, G
Single settings with coupling housing; mounting plate





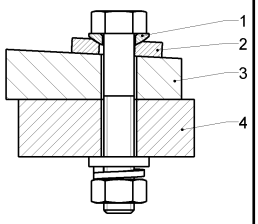
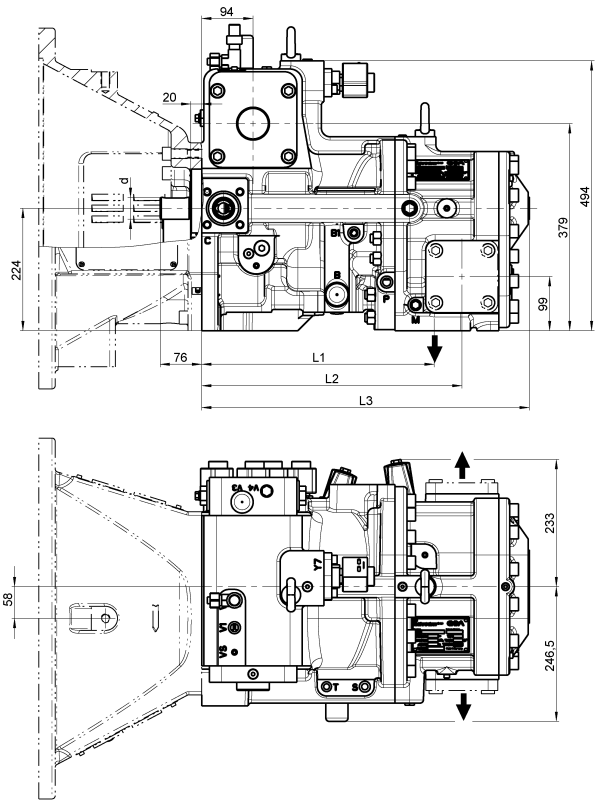


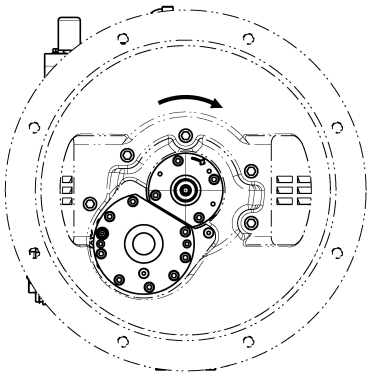
Fig.6

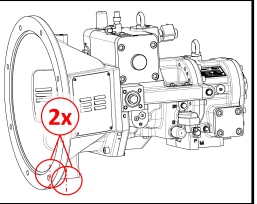
1	Spherical washer
2	Conical seal
3	Coupling housing
4	Screw Compressor Package

Main dimensions, connection dimensions Single settings with coupling housing; mounting plate			
Main dimensions		**Compressor <u>without</u> coupling housing and coupling**	
		Frame size E	**Frame size G**
l1 [mm]		425.5	454.5
l2 [mm]		476	505
l3 [mm]		599.5	628.5
Drive shaft diameter d [mm]		40 h6 (28 bar)	40 h6 (28 bar)
		45 h6 (52 bar)	45 h6 (52 bar)
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. Weight (kg) with/without Coupling housing		444 / 344	451 / 351
For the dimensions of the coupling housing see Section 6.3, Page 32 and the following:			

Frame Sizes E, G
Single settings with coupling housing; direct fixing







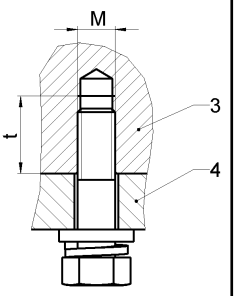
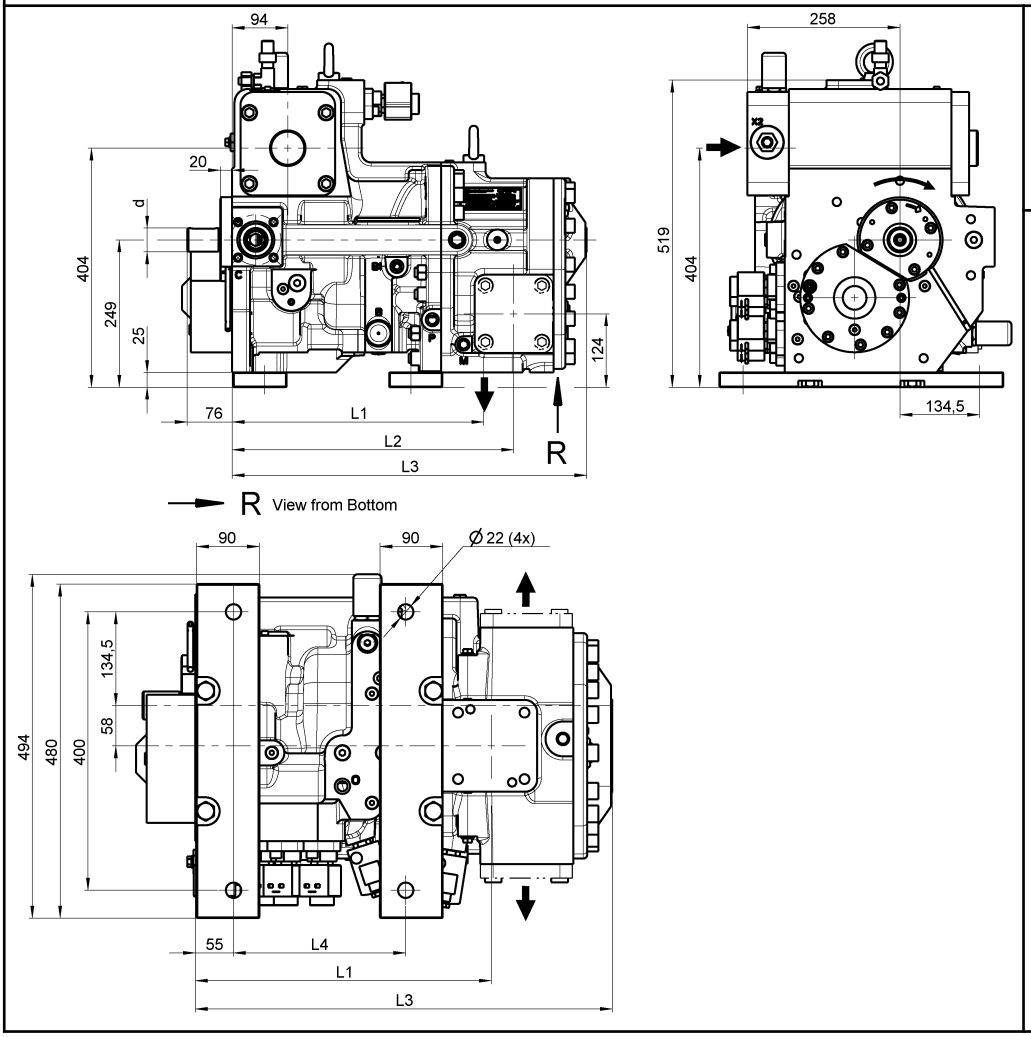


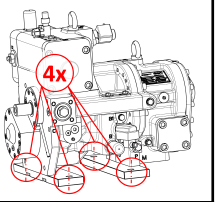
Fig.7

3	Coupling housing
4	Screw Compressor Package
M	M20
t	35 mm

Main dimensions, connection dimensions Single settings with coupling housing; direct fixing			
Main dimensions		**Compressor <u>without</u> coupling housing and coupling**	
		Frame size E	**Frame size G**
l1 [mm]		425.5	454.5
l2 [mm]		476	505
l3 [mm]		599.5	628.5
Drive shaft diameter d [mm]		40 h6 (28 bar)	40 h6 (28 bar)
		45 h6 (52 bar)	45 h6 (52 bar)
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. Weight (kg) with/without Coupling housing		444 / 344	451 / 351
For the dimensions of the coupling housing see Section 6.3, Page 32 and the following:			

Frame Sizes E, G
Single settings with mounting plate





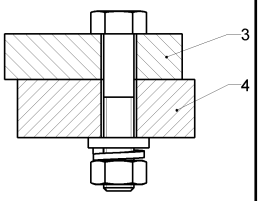
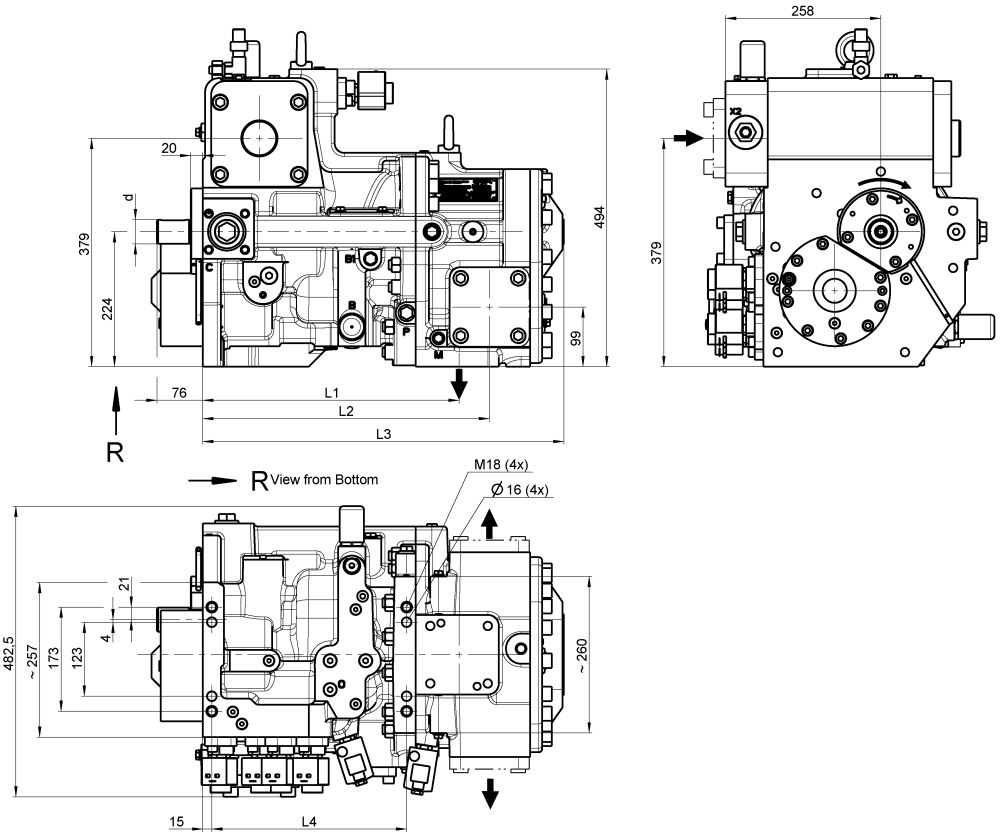


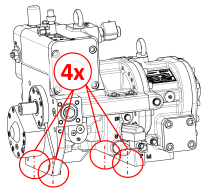
Fig.8

3	Mounting plate
4	Screw Compressor Package

Main dimensions, connection dimensions Single settings with mounting plate			
Main dimensions		**Compressor**	
		Frame size E	**Frame size G**
l1 [mm]		425.5	454.5
l2 [mm]		476	505
l3 [mm]		599.5	628.5
l4 [mm]		247.5	276.5
Drive shaft diameter d [mm]		40 h6 (28 bar)	40 h6 (28 bar)
		45 h6 (52 bar)	45 h6 (52 bar)
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. Weight (kg)		344	351

Frame Sizes E, G
Single setting





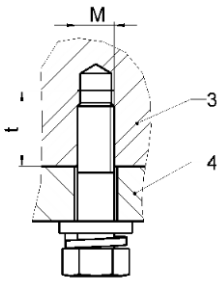
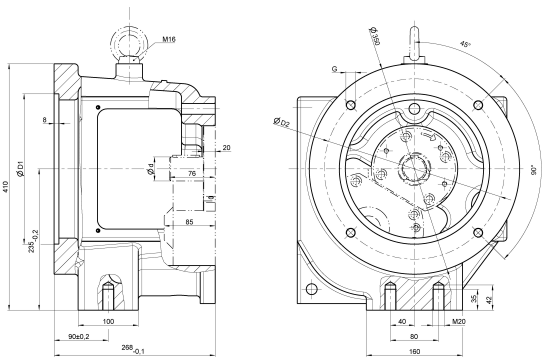
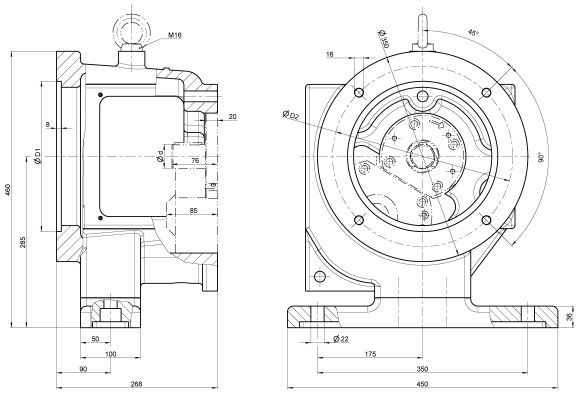


Fig.9

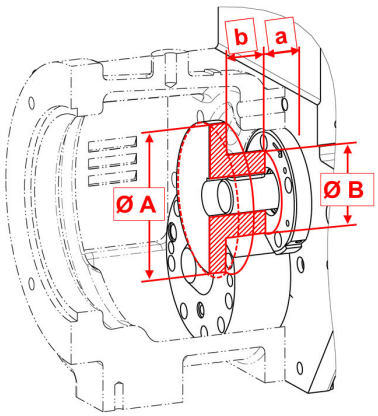
3	Compressor
4	Screw Compressor Package
M	M16
t	34 mm

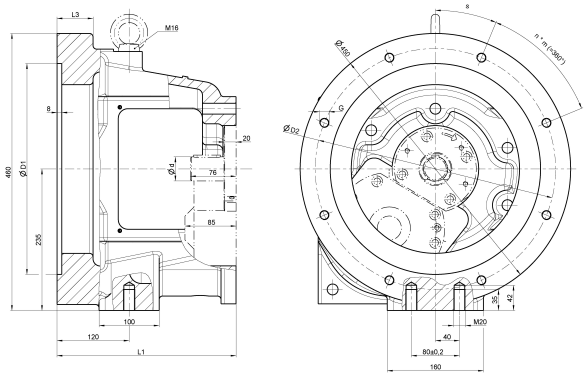
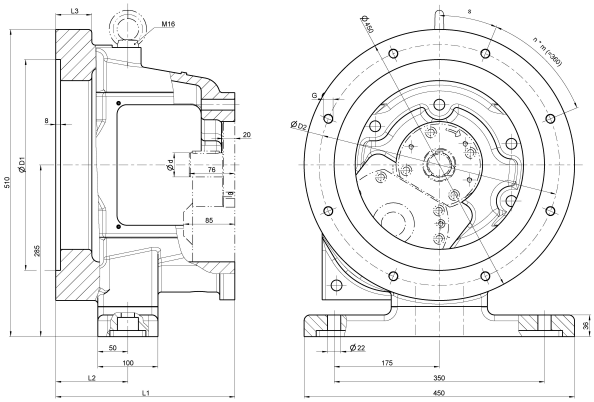
Main dimensions, connection dimensions Single setting			
Main dimensions		**Compressor**	
		Frame size E	**Frame size G**
l1 [mm]		425.5	454.5
l2 [mm]		476	505
l3 [mm]		599.5	628.5
l4 [mm]		323.5	352.5
Drive shaft diameter d [mm]		40 h6 (28 bar)	40 h6 (28 bar)
		45 h6 (52 bar)	45 h6 (52 bar)
Connection	Suction side	DN 80	DN 80
	Discharge side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. Weight (kg)		344	351

6.3 Coupling housing
for compressor frame sizes C, D, E, G

Coupling housing; IEC, NEMA; centring bush Ø 250 ; Ø 11 inch	
without mounting plate	**with mounting plate**
	

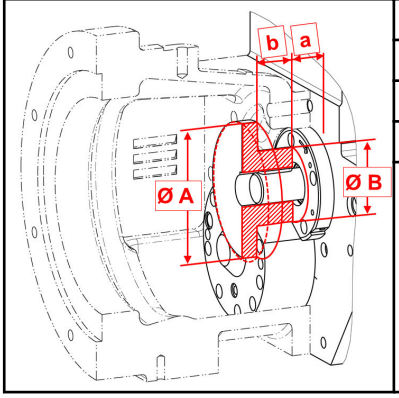
Coupling housing Frame size 12, IEC, NEMA Centring bush Ø 250 ; Ø 11 inch		**Model**	
		0820000	**0820139**
Centering hub diameter	D1	250	11 inch
Pitch diameter of the motor bracket	D2	300	12.5 inch
Thread for motor bracket	G	4x M16	
Drive shaft diameter	d	40 h6 (28 bar)	
		45 h6 (52 bar)	
Mounting screws Coupling housing - unit frame		M20	
Maximum allowable torque on the motor flange by motor weight		2000 Nm	
Maximum allowable torque on the motor flange by motor overturning moment		1500 Nm	

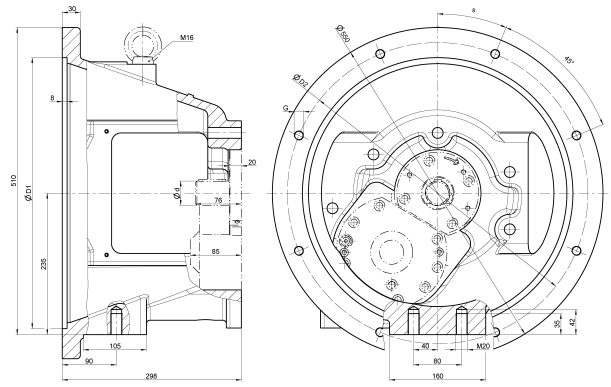
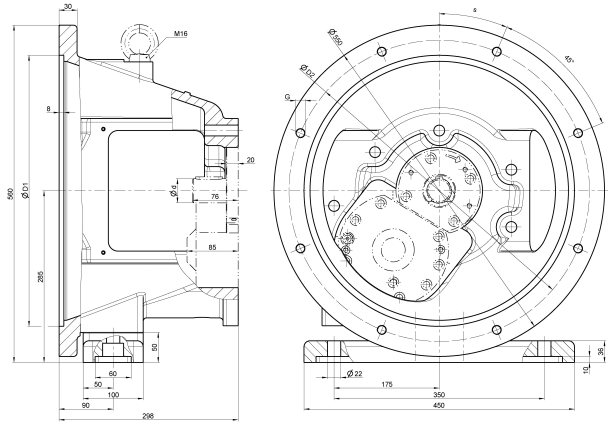
Space for coupling, compressor-side				
	Coupling housing Frame size 12, IEC, NEMA Centring bush Ø 250 ; Ø 11 inch		**Compressor frame size**	
			C, D	**E, G**
	Hub flange diameter	Ø A	≤ 145 mm	≤ 175 mm
	Hub diameter	Ø B	≤ 85 mm	≤ 95mm
	Mounting dimension	a	≥ 25 mm	≥ 25 mm
	Distance	b	≥ 50 mm	≥ 50 mm

Coupling housing; frame size 13, IEC, NEMA; centring bush Ø 350 ; Ø 300; Ø 14 inch	
without mounting plate	**with mounting plate**
	

Coupling housing **Frame size 13, IEC, NEMA** **Centring bush Ø 350 ; Ø 300; Ø 14 inch**		**Model**			
		0820002	**0820005**	**0820006**	**0820007**
Centering hub diameter	D1	350	350	300	14 inch
Pitch diameter of the motor bracket	D2	400	400	350	16 inch
Thread for motor bracket	G	8x M16	8x M16	4x M16	4x M16
Start angle of the thread	s	22.5°	22.5°	45°	45°
Drive shaft diameter	d	40 h6 (28 bar)			
		45 h6 (52 bar)			
Coupling housing length	L1	268	298	268	268
Distance motor flange - frame bracket coupling housing	L2	90	120	90	90
Mounting screws Coupling housing - unit frame		M20			
Maximum allowable torque on the motor flange by motor weight		2500 Nm			
Maximum allowable torque on the motor flange by motor overturning moment		1500 Nm			

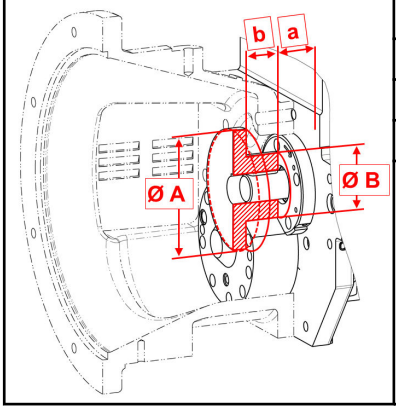
Space for coupling, compressor-side

	Coupling housing **Frame size 13, IEC, NEMA** **Centring bush Ø 350 ; Ø 300; Ø 14 inch**		**Compressor frame size**	
			C, D	**E, G**
	Hub flange diameter	Ø A	≤ 145 mm	≤ 175 mm
	Hub diameter	Ø B	≤ 85 mm	≤ 95mm
	Mounting dimension	a	≥ 25 mm	≥ 25 mm
	Distance	b	≥ 50 mm	≥ 50 mm

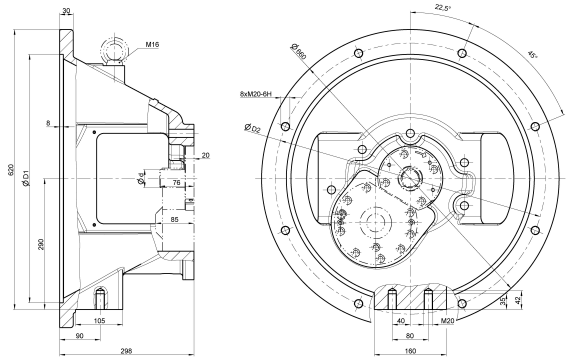
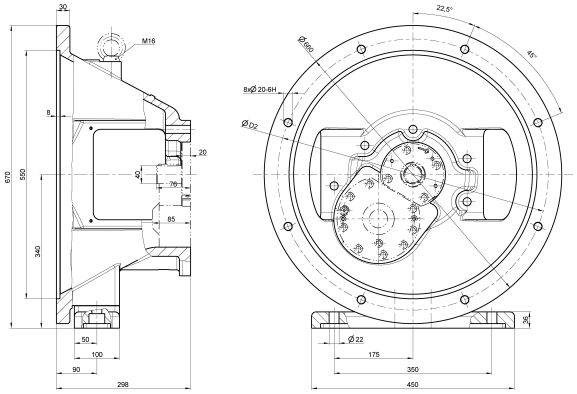
Coupling housing; frame size IEC, NEMA; centring bush Ø 450; 18 inch	
without mounting plate	**with mounting plate**
	

Coupling housing **Frame size 14, IEC, NEMA** **Centring bush Ø 450 ; Ø 18 inch**		**Model**	
		0820004	**0820008**
Centering hub diameter	D1	450	18 inch
Pitch diameter of the motor bracket	D2	500	20 inch
Thread for motor bracket	G	8x M16	8x M20
Start angle of the thread	s	22.5°	0
Drive shaft diameter	d	40 h6 (28 bar)	
		45 h6 (52 bar)	
Mounting screws Coupling housing - unit frame		M20	
Maximum allowable torque on the motor flange by motor weight		2900 Nm	
Maximum allowable torque on the motor flange by motor overturning moment		1500 Nm	

Space for coupling, compressor-side

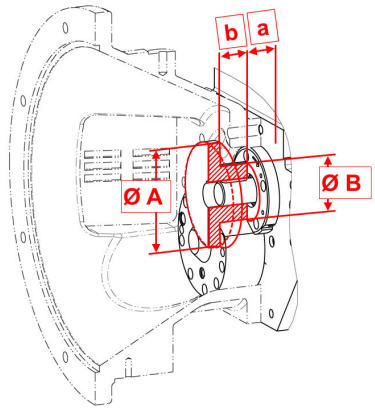


Coupling housing **Frame size 14, IEC, NEMA** **Centring bush Ø 450 ; Ø 18 inch**		**Compressor frame size**	
		C, D	**E, G**
Hub flange diameter	Ø A	≤ 145 mm	≤ 175 mm
Hub diameter	Ø B	≤ 85 mm	≤ 95mm
Mounting dimension	a	≥ 25 mm	≥ 25 mm
Distance	b	≥ 50 mm	≥ 50 mm

Coupling housing; frame size IEC; centring bush Ø 550	
without mounting plate	**with mounting plate**
	

Coupling housing **Frame size IEC** **Centring bush Ø 550**		**Model**
		0819882
Centering hub diameter	D1	550
Pitch diameter of the motor bracket	D2	600
Thread for motor bracket	G	4x M20
Drive shaft diameter	d	40 h6 (28 bar)
		45 h6 (52 bar)
Mounting screws Coupling housing - unit frame		M20
Maximum allowable torque on the motor flange by motor weight		4850 Nm
Maximum allowable torque on the motor flange by motor overturning moment		1500 Nm

Space for coupling, compressor-side

	Coupling housing **Frame size IEC** **Centring bush Ø 550**		**Compressor frame size**	
			C, D	**E, G**
	Hub flange diameter	Ø A	≤ 145 mm	≤ 175 mm
	Hub diameter	Ø B	≤ 85 mm	≤ 95mm
	Mounting dimension	a	≥ 25 mm	≥ 25 mm
	Distance	b	≥ 50 mm	≥ 50 mm

6.4 Connections Types C, D, E, G

P+I DIAGRAMM

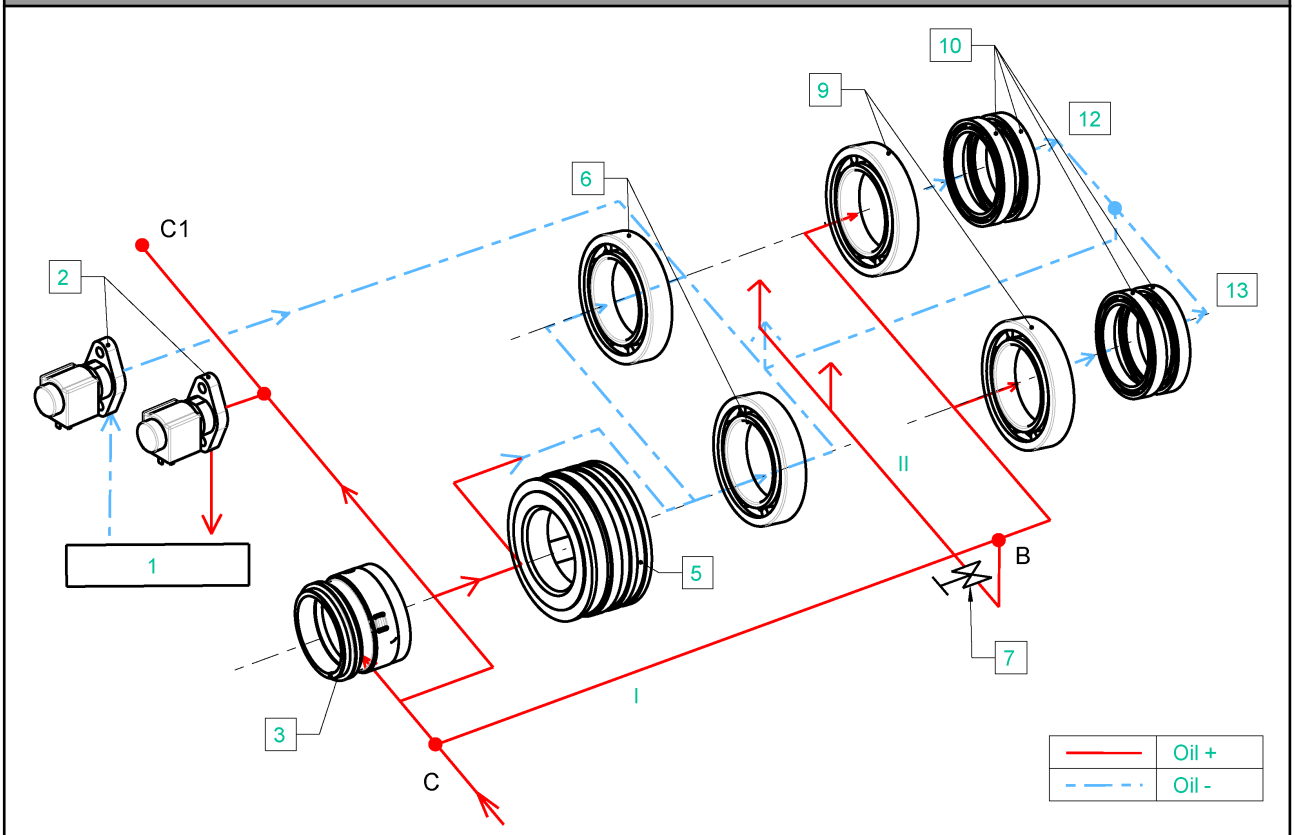
Notice

General note on P+I diagram.

► The P+I diagram applies to the screw compressor only.
► The P+I diagram for the screw compressor only shows the connecting conditions to the screw compressor package.
► The P+I diagram of the screw compressor does not consider the piping scheme and the safety devices of the screw compressor package.
► The nameplate of each compressor is marked with the pertaining P+I number of the screw compressor.
► The specified oil supply diagram of the compressor is part of the documentation and will be supplied with the compressor.

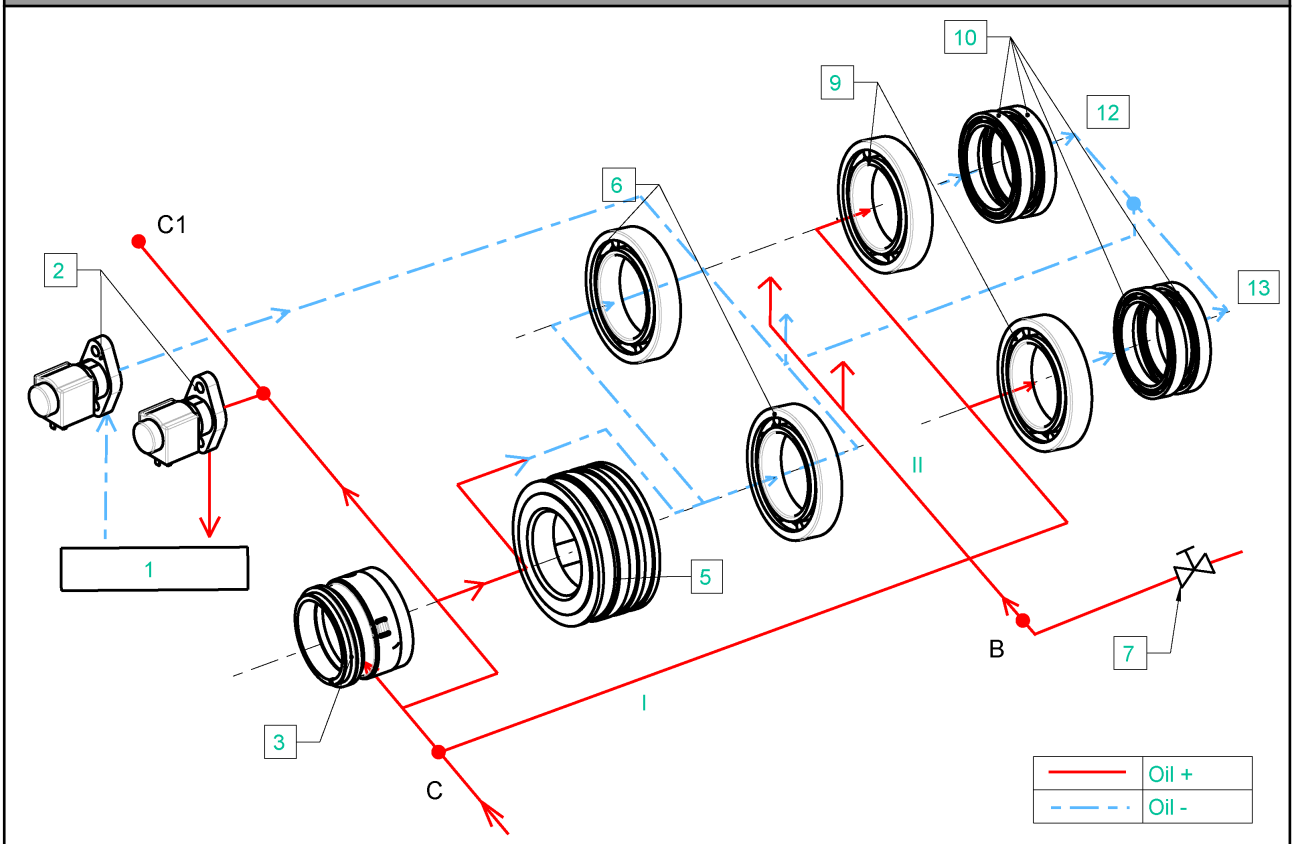
P+I diagrams are available for connecting the package oil circuit to the compressor, which will be determined based on the usage of the machines and have special labels.

Central oil supply for functional oil and injection oil



Oil +	Oil feed; oil flow inside the compressor (high pressure)	1	Capacity control/ Vi adjustment
Oil -	Oil flow inside the compressor (low pressure)	2	Solenoid valves ; Capacity control/ Vi adjustment
		3	Shaft Seal
C / C1	Oil supply; functional oil, injection oil	5	Balance piston
B, 7	Injection oil quantity adjustment	6	Radial bearing of the rotors (suction side)
		7	Injection oil quantity adjustment
I	Oil channel: functional oil discharge side, injection oil	9	Radial bearing of the rotors (discharge side)
II	Oil channel: injection oil to working chamber	10	Thrust bearing of the rotors
		12, 13	Oil return of the bearing oil of the discharge side in the direction of the working chamber

Separate oil supply for functional oil and injection oil



Oil +	Oil feed; oil flow inside the compressor (high pressure)	1	Capacity control/ Vi adjustment
Oil -	Oil flow inside the compressor (low pressure)	2	Solenoid valves ; Capacity control/ Vi adjustment
		3	Shaft Seal
C / C1	Oil feed; functional oil	5	Balance piston
B	Oil feed; injection oil	6	Radial bearing of the rotors (suction side)
		7	Injection oil quantity adjustment
I	Oil channel: functional oil discharge side, injection oil	9	Radial bearing of the rotors (discharge side)
II	Oil channel: injection oil to working chamber	10	Thrust bearing of the rotors
		12, 13	Oil return of the bearing oil of the discharge side in the direction of the working chamber

CONNECTIONS

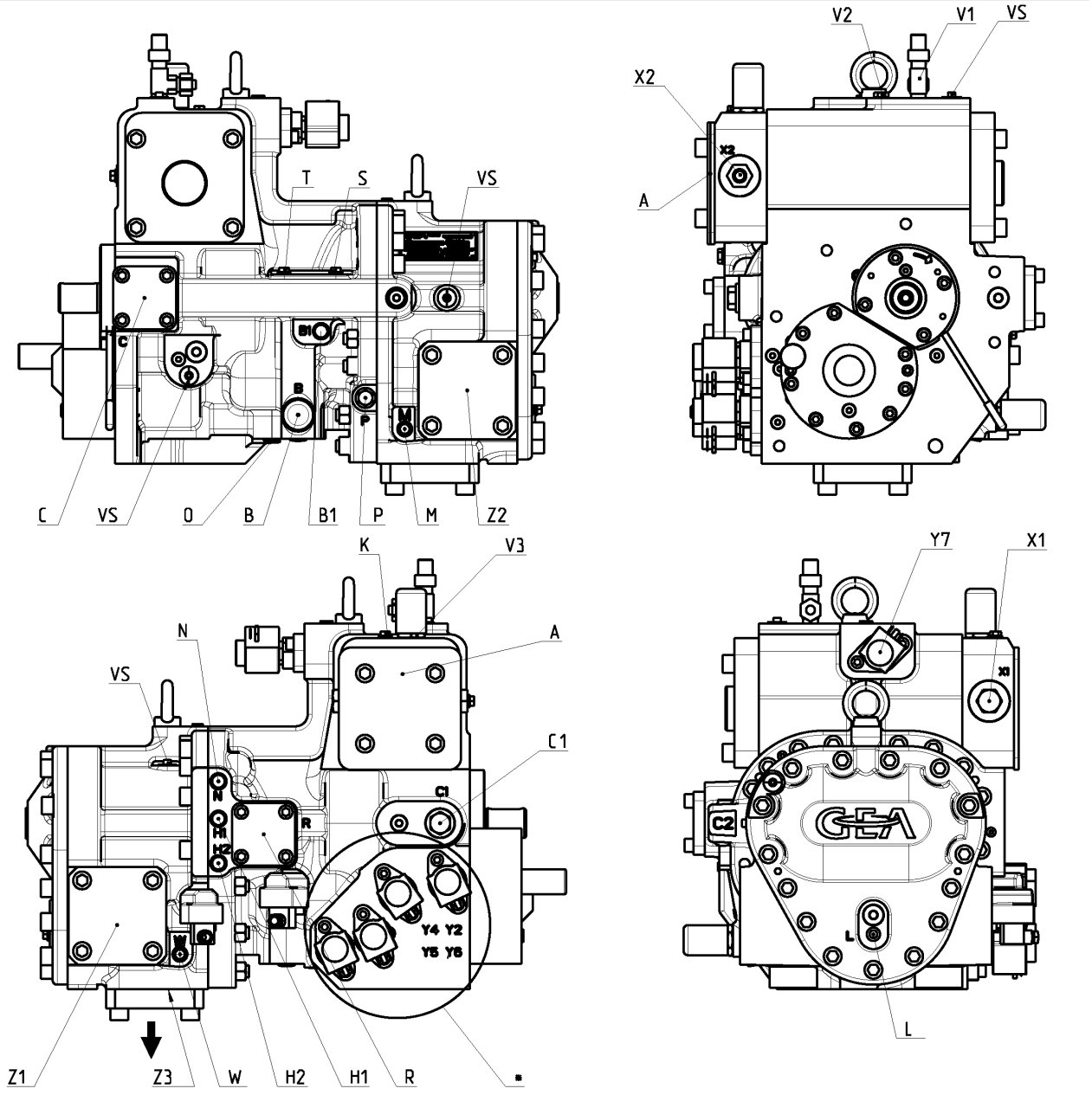


Fig.10: Connections, example: frame size E, Vi-variable

*	solenoid valves, description, function and arrangement depending on compressor-design and -execution, see Page 43

PIPE CONNECTIONS / THREADS			
Connection	**Purpose**	**Nominal diameter/thread**	
		Compressor frame size	
		C, D	**E, G**
A	Suction nozzle	DN 80 *	DN 80 *
B	Injection oil quantity adjustment Optional: external injection oil supply	G ¾"	
B1	Additional oil injection	M16 x 1.5	
C	Function- and injection oil	M33 x 2	
C1	Function- and injection oil Optional to connection C	M33 x 2	
	Optional: external oil supply for solenoid valve when function- and injection oil via connection C	M16 x 1.5	
C2	Option: function oil bearings discharge housing	M16 x 1.5	
H1	Refrigerant injection (LP)	M16 x 1.5	
H2	Refrigerant injection (HP)	M16 x 1.5	
K	Measuring suction pressure	G ¼	
L	Measuring discharge temperature	M12 x 1.5	
M	Measuring discharge pressure	G ¼	
N	Oil return from oil separator	M16 x 1.5	
O	Oil drain plug	M16 x 1.5	
P	Gas vibration protection	M16 x 1.5	
R	Economizer	DN 40 *	
S	Measuring oil pressure	G ¼	
T	Measuring oil temperature	M12 x 1.5	
V1	Service port suction side Vent valve	M16 x 1.5	
V2	Service port suction side post filter, check valve	M16 x 1.5	
V3	Integrated service valve, bypass suction side check valve	M24 x 1.5	
VS	Vibration sensor connection	¼ " -28 UNF x 10	
W	Service port discharge side	M10 x 1	
X1	Overflow valve connection	M48 x 2	
X2	Measuring suction temperature	M12 x 1.5	
Z1, Z2, Z3	Discharge nozzle	DN 65 *	DN 80 *

Flange connection required, see tables Page 42, Page 42

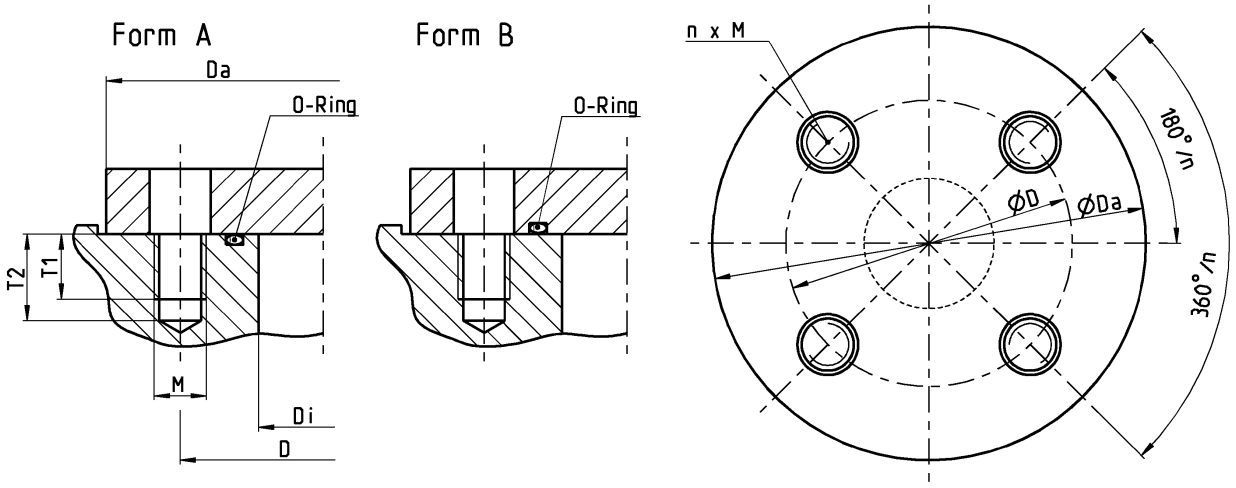
Notice

Oil filtering

► If there is no oil filter module fitted in the compressor package, an oil filter module configured by the manufacturer can be fitted directly on connection C of the compressor.
► Connections for monitoring the oil circuit as well as service ports are located on the oil filter module.

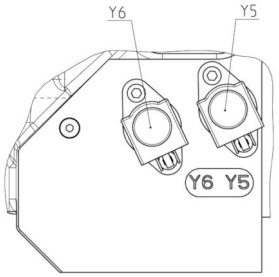
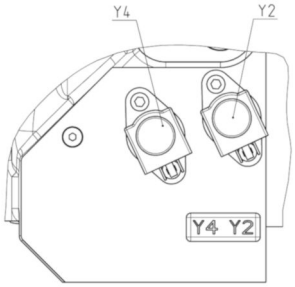
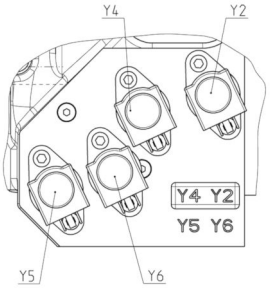
ELECTRICAL CONNECTIONS				
Connection	**Purpose**		**Inlet**	**Outlet**
U1	Position sensor: position display control slide / Vi-slide		24 V (DC)	4 - 20 mA
U2	Position sensor: position display control slide stop		24 V (DC)	4 - 20 mA
Y1	Solenoid valve	The function of each solenoid valve is described in the chapter "Solenoid valves" of Installation- and Maintenance manual.	220 V/ 230 V AC 110 V AC 24 V DC 230 V / 240 V AC, ATEX 110 V/ 120 V AC, ATEX 24 V DC, ATEX	
Y2	Solenoid valve			
Y3	Solenoid valve			
Y4	Solenoid valve			
Y5	Solenoid valve			
Y6	Solenoid valve			
Y7	Solenoid valve (NO)	Hot gas pressurized check valve		

Flange connections



Flange connections, compressor frame sizes C, D				
	Suction nozzle A	**Discharge nozzle Z1; Z2**	**Discharge nozzle Z3**	**Economizer R**
Di	Ø 92	Ø 65	Ø 65	Ø 44
D	Ø 135	Ø 108	Ø 135	Ø 85
Da	□ 165	□ 112	Ø 170	□ 85
M	M16	M16	M16	M12
T1	34	34	34	27
n	4	4	4	4
Form	B	B	B	A
O-Ring	100 x 5	70 x 5	100 x 5	55 x 3

Flange connections, compressor frame sizes E, G				
	Suction nozzle A	**Discharge nozzle Z1, Z2**	**Discharge nozzle Z3**	**Economizer R**
Di	Ø 92	Ø 80	Ø 80	Ø 44
D	Ø 135	Ø 135	Ø 135	Ø 85
Da	□ 165	□ 132	Ø 170	□ 85
M	M16	M16	M16	M12
T1	34	34	34	27
n	4	4	4	4
Form	B	B	B	A
O-Ring	100 x 5	100 x 5	100 x 5	55 x 3

Description, arrangement of solenoid valves			
Design	**Compressor design**	**Vi**	**Detail * from connection diagram**
"S"	"T" Triax	Vi variable	
"M"	"S" Standard "T" Triax	Vi fixed	
		Vi variable	
	"B" Booster	Vi fixed	

6.5 Conditions for Refrigerant Connections

Connection	Filter mesh size	Remarks
Suction nozzle upstream of the compressor	100 µm	
Pressure nozzle		During pressure compensation after stopping of the compressor, care should be taken to prevent foreign matter from getting into the compressor together with refrigerant vapour flowing back from the plant components arranged downstream of the compressor.
	100 µm	A filter can be used as an option.
Economizer connection upstream of the compressor	100 µm	Area of application between 100% and approx. 70% control slide position, depending on the refrigerant requirements. At economiser operation during part-load operation, care should be taken to maintain the projected intermediate pressure.
Refrigerant injection connection upstream of the compressor	100 µm	Refrigerant injection should only be used in conjunction with inertia-free temperature measurement on the compressor pressure side (time constant k < 10 sec). When operating with refrigerant injection, the regulating valve should be sized to ensure that no liquid refrigerant enters the oil separator downstream.

⚠ Caution!

Destruction of the filters and the compressor by suctioned liquids

Liquid (refrigerant or oil) can lead to destruction of the filter at the suction nozzle and economizer connection.

► Ensure that no liquids are suctioned.

Notice

Practical advice Design of the connection pipelines!

► Due to the screw compressors working principles, dynamic pressure points occur proportionally to the drive speed multiplied by the number of teeth on the male rotor on the connection with the screw compressor. These loads need to be included when designing the connection pipes.

Notice

Instruction for routing the pipe at the discharge connection

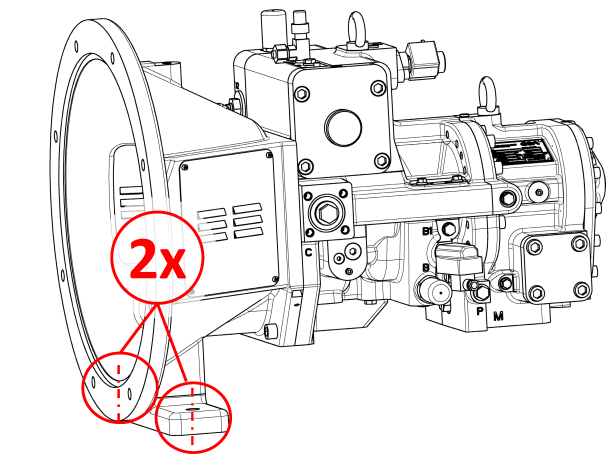
► The piping must be laid in such a way that liquids can drain freely from the compressor into the oil separator.

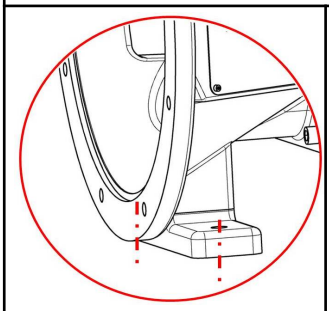
6.6 Installation of the compressor

Installation conditions:	
compressor mounting surface	- overall evenness of mounting feet: 0.5 mm - support thickness: ≥ 25 mm

Mounting the compressor

Single setting with coupling housing and mounting plate





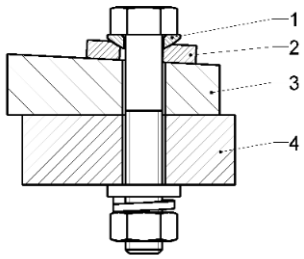
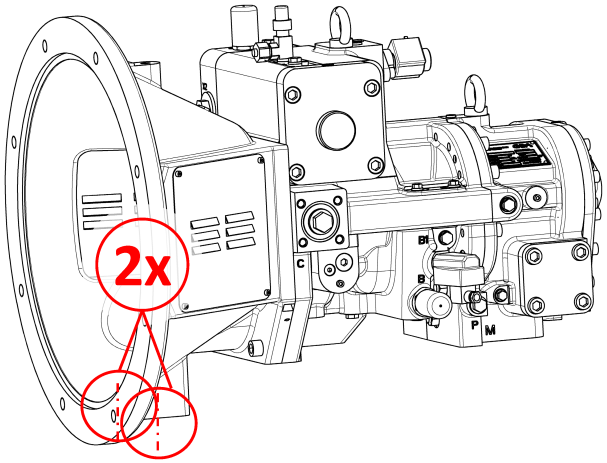
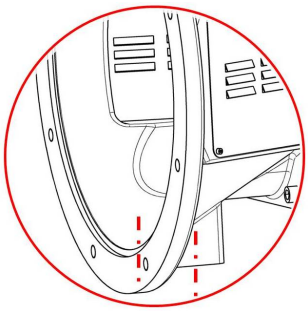


Fig.11

1	Spherical washer
2	Conical seal
3	Coupling housing
4	Screw Compressor Package

Single setting with coupling housing, Direct fixing





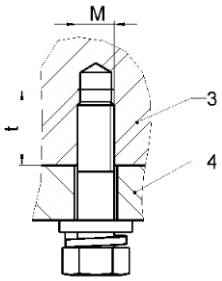


Fig.12

3	Coupling housing
4	Screw Compressor Package
M	M20
t	35 mm

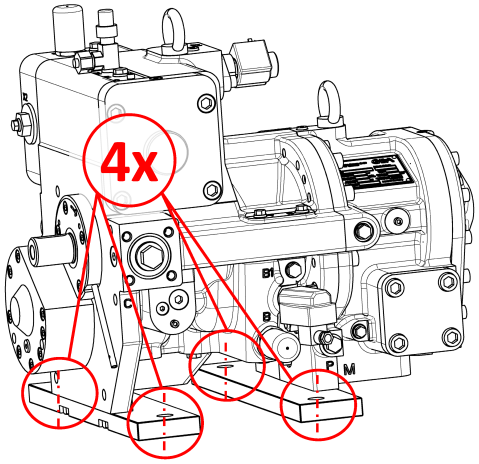
Notice

Information on the safe stability and safe function of the compressor.
► The height and angle offset between the pressure nozzle and the supporting surface of the coupling housing must be compensated.

During the annual maintenance of the compressor, the mounting screws of the compressor must be retightened to the tightening torques given in the table Page 47.

Mounting the compressor

Single setting with mounting plate



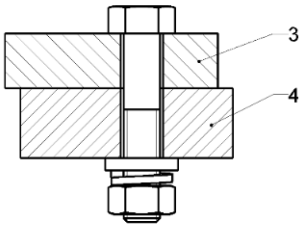


Fig.13

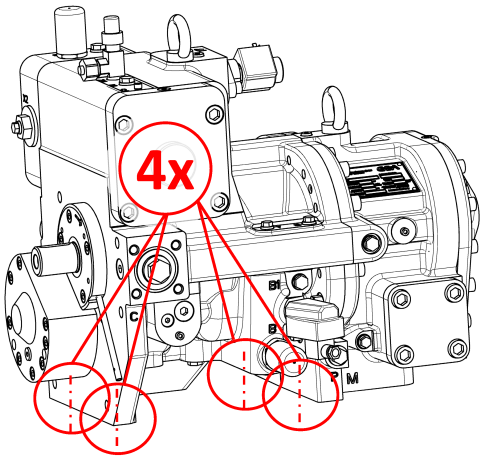
3	Mounting plate, screwed with the compressor
4	Screw Compressor Package

Notice

Information on the safe stability and safe function of the compressor.

► The height and angle offset between the pressure nozzle and the supporting surface of mounting plate must be compensated.

Single setting



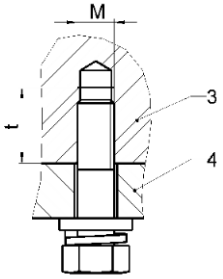


Fig.14

3	Compressor
4	Screw Compressor Package
M	M16
t	34 mm

Notice

Information on the safe stability and safe function of the compressor.

► The height and angle offset between the pressure nozzle and the supporting surface of the compressor housing must be compensated.

During the annual maintenance of the compressor, the mounting screws of the compressor must be retightened to the tightening torques given in the table Page 47.

Required tightening torque of the mounting screws of the compressor		
Compressor- Frame size	**Screw/thread**	**Tightening torque[1)][Nm]**
C, D, E, G with coupling housing, Mounting plate	M16	210
C, D, E, G with coupling housing, Direct fixing	M20	425
C, D, E, G Single setting, Mounting plate	M20	425
C, D, E, G Single setting,	M16	210
[1)] based on screw quality 8.8 and friction coefficient 0.14		

Drive motor, coupling

For single setting without coupling housing, the alignment of the drive motor to the compressor must be done according to the requirements of the coupling manufacturer. Familiarise yourself with the installation instructions of the coupling manufacturer and use them according to these instructions. The alignment of the drive motor must be repeated after the initial assembly at operating temperature. Retain a logged record of the alignment.

6.7 Technical requirements for couplings

When using a coupling not supplied from the manufacturer the following conditions need to be met:

Parameter		Compressor frame size	
		C, D	E, G
			28 bar
			52 bar
Max. Driving power (60 Hz)	kW	180	180
			265
Nominal torque	Nm	500	500
			710
Max. Start-up torque	Nm	1250	1250
			1750
Max. Speed	rpm	6000	
Maximum dynamic unbalance allowable	gcm	20	
permissible radial force F_R [1)]	N	500	
permissible axial force F_A	N	200	
shaft diameter Compressor [*]	mm	40 h6	40 h6
			45 h6
min. distance between Shaft ends compressor/motor[2)]	mm	60 $^{+5}$	

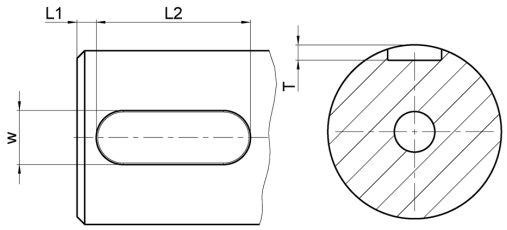
[*] E/G frame size compressors at 28 bar and 52 bar have different drive shaft ends.

[1)] Permissible forces that may impact the compressor shaft end. The selection of coupling and the orientation are to be set up so that this force is not exceeded.

[2)] Values apply to simply functioning mechanical shaft seals (Standard). When using double mechanical seals contact needs to be made with manufacturer.

The maximum permitted drive capacities listed are upper limits determined by the drive shaft ends. Due to wear on the bearings, these drive forces shall not be achieved within a compressor size for all the available flow volumes. The review will be carried out in the compressor selection program.

Further conditions:	
design of the compressor shaft end:	cylindrical with feather key.
attachment of the compressor shaft end:	positively connected via feather key, with additional stack assembly.
Direction of rotation:	clockwise and counter clockwise
Start up and shut down frequency	maximum 10 per hour
operating temperature range:	- 20 °C to + 55 °C for dynamic operating load

Shaft end of the compressor			
		Compressor frame size Pressure stage	
		C, D, E, G 28 bar	**E, G 52 bar**
	D	40 h6	45 h6
	L1	5	5
	L2	45	40
	W	12	14
	T	5	4

6.8 Vibrations, sound, permissible piping loads; frame sizes C, D, E, G

Vibrations				
Main excitation frequencies	**Speed**			
	3000 rpm	**3600 rpm**	**4500 rpm**	**6000 rpm**
f^1	50	60	75	100
f^2	100	120	150	200
f^3	250	300	375	500
f^4	500	600	750	1000

Balance grade	
Balance grade of rotors	**Compressor frame size**
	C, D, E, G
Balance grade G (mm/s) acc. DIN ISO 21940	G 6,3

Vibration limit values	
Compressor frame size	**Effective vibration velocity/ RMS [1)]** **in frequency range A between 10 and 1000 Hz [2)]**
	Permissible limit value (mm/s)[3)4)5)6)]
C, D, E, G	4.0

1) Measuring method according to DIN ISO 10816.

2) Frequency range to be measured, minimum up to 1000 Hz; above 4000 rpm, minimum up to 1500 Hz

3) In case of rigid installation of compressor.

4) The installation of compressor as well as the design of frame and pipes of the package must be considered so that the limit values of vibration velocity do not exceed.

5) Limit values are valid up to 3000 rpm. For a speed of 3600 rpm and higher the limit value must be multiplied by 1.2.

6) The expected value of effective vibration velocity during trouble-free continuous operation is 50% of the above mentioned limit value with optimal frame design.

Recommended monitoring limits:

WARNING: 75... 100% of the permissible limit value

SHUTDOWN: 115...140% of the permissible limit value

Notice

Practical note: Limit values standstill monitoring, standstill measurement

If the effective vibration velocity measured at standstill is more than 25% of the specified limit value:

► Reduce the influence of the spurious oscillations.
► Avoid sudden excitations.

Mass moment of inertia, torsional stiffness of the compressor rotor pair

Notice

Prescription Torsional analysis of drive train

► Careful mechanical design and construction of the compressor unit.
► Performance of a torsional analysis of the drive train to ensure safe operation outside the critical torsional natural frequencies.

The values of the mass moment of inertia and torsional stiffness of the compressor rotor pair required for the torsion analysis are given in the table below. The values are valid for compressors with a maximum discharge pressure of 28 bar in compressor designs "B", "S", "R". Values for different compressor designs can be obtained from the manufacturer.

Values for torsional analysis				
	Compressor frame size			
	C	D	E	G
Mass moment of inertia [kg m^2]	0.0325	0.0385	0.0618	0.0716
Torsional stiffness [kNm/rad]	110	110	113	113

Sound

Emitted sound values					
Compressor frame size		**C**	**D**	**E**	**G**
Sound power level L_{WA}	dB (A)	82	83	84	85
Emission sound pressure level L_{pA}	dB (A)	68	69	70	71

The sound power of the compressor depends on its capacity and varies with the operating conditions of the plant. The emitted sound is caused by the compression process, gas pulsations and vibrations. The noise level is strongly influenced by the interaction between the compressor and the compressor package. In practice, the sound power levels may differ from the specified values.

The indicated values apply only for the following operating conditions with a variation of ± 3 dB:

- Speed n=2900 ... 3100 rpm
- Oil temperature 45...55 °C
- Medium NH3 (R717)
- Operating points t_0/t_c [°C]: 5/50; -10/45; -35/40; without economizer
- Operating points p_0/p_c [bar.a]: 5,2/20,3; 2,9/17,8; 0,96/15,5; without economizer

The inner volume ratio must be the best Vi value calculated in the compressor selection program for the specified operating point.

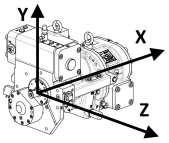
The emission sound pressure level L_{pA} in dB(A) at a distance of 1 m from the machine surface (A near level with free field conditions on a reflective base area) is a table value reduced by 13 to 17 dB(A) compared to the sound power level L_{WA}.

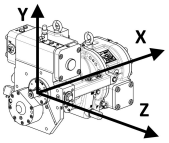
L_{WA}:	A-weighted sound power level according to DIN EN ISO 9614-2 and DIN 45635, reference: 1 pW
L_{pA}:	A-weighted emission sound pressure level at 1 m distance according to DIN EN ISO 11203, reference: 20 µPa

Notice

Information on the dimensioning of pipes.

► Due to the working principle of the screw compressor, dynamic pressure points occur at the connections of the screw compressor, particularly at the pressure nozzle, at a frequency that is proportional to the drive speed multiplied by the number of teeth of the male rotor.
► The design of the connecting pipelines must consider the critical pipe lengths depending on the speed of sound, in order to avoid resonances.
► The sound emission of the package is significantly influenced by such pressure pulsations in piping systems.

PERMISSIBLE PIPING FORCES AND TORQUES: including gas forces					
Maximum permitted pressure	**Point of application**		**Vector** 	**Compressor frame size**	
				C/D	**E/G**
28 bar	Suction nozzle: Screw Strength class A2-70	Force [N]	|x|	900	900
			$\|y_{max}\|$	900	900
			$\|y_{min}\|$	-900	-900
			|z|	900	900
		Torque [Nm]	|x|	400	400
			|y|	400	400
			|z|	400	400
	Discharge nozzle: Screw Strength class 8.8	Force [N]	|x|	1100	1200
			|y|	1100	1200
			|z|	1100	1200
		Torque [Nm]	|x|	500	500
			|y|	500	500
			|z|	500	500
	Eco nozzle: Screw Strength class A2-70	Force [N]	|x|		
			|y|		
			|z|		
		Torque [Nm]	|x|		
			|y|		
			|z|		

PERMISSIBLE PIPING FORCES AND TORQUES: including gas forces					
Maximum permitted pressure	**Point of application**		**Vector** 	**Compressor frame size**	
				C/D	**E/G**
52 bar	Suction nozzle: Screw Strength class A2-70	Force [N]	|x|	600	600
			$\|y_{max}\|$	600	600
			$\|y_{min}\|$	-600	-600
			|z|	600	600
		Torque [Nm]	|x|	200	200
			|y|	200	200
			|z|	200	200
	Discharge nozzle: Screw Strength class 8.8	Force [N]	|x|	1000	1000
			|y|	1000	1000
			|z|	1000	1000
		Torque [Nm]	|x|	400	400
			|y|	400	400
			|z|	400	400
	Eco nozzle: Screw Strength class A2-70	Force [N]	|x|		
			|y|		
			|z|		
		Torque [Nm]	|x|		
			|y|		
			|z|		

6.9 Operation limits

The compressor and the installed components are designed for specific operating conditions which must be maintained for safe working of the compressor.

⚠ Caution!

Damage to the compressor and compressor package

► The following specified minimum and maximum limit values must be adhered to.
► The design-related maximum pressure as per the nameplate must not be exceeded.
► Beyond that, project-specific restrictions or limit values, which must be agreed separately, apply.

Process parameters					
Permissible pressure (EN 378) (Gauge pressure)	p	max	28 bar / 52 bar, according to the nameplate		
Suction temperature [4]	t_{0h}	min	- 60 °C		
Discharge temperature	t_e	max	120°C		
Pressure ratio	p_c / p_0	min	1.5 [5]		
		max	22		
Pressure difference	p_c - p_0		Standard operation with / without oil pump:[6] 28 bar / 52 bar	Booster operation: [7] 28 bar	Application "SWING": [8] 28 bar
			min. 2.9 bar *	min. 0.8 bar max. 2.9 bar	min. 0.8 bar
Oil temperature	t_{oil}	min	18°C		
		max	80°C		
Oil pressure [9]	p_{oil}		**Operation without oil pump:**	**Operation with oil pump:**	
			$p_{oil} \geq p_0$ + 2 bar [10]	$p_{oil} \geq p_0$ + 2 bar [10]	
				AND	
			AND	$p_{oil} \leq p_c$ + 3.5 bar [11]	
			$p_{oil} \geq p_c$ - 3 bar [10] $p_{oil} \leq p_c$ [12]	AND	
				$p_{oil} \geq p_c$ + 0,5 bar	
Oil viscosity [13]	v	min	7 mm^2/s		
		max	70 mm^2/s		
Suction filter mesh	W_s	max	100 µm		

4 A dry-saturated steam has to be ensured during the suction process (no liquid).
5 For compressors with reduced volume flows, this value could be exceeded.
6 compressors design "S", compressors design "M" with fixed and variable Vi.
7 with oil pump; compressors design "M", compressor design "B".
8 with oil pump; compressors design "M" with fixed Vi, equipped for "SWING" application.
9 The specified oil pressures are limit values. The compressor must be switched off when exceeding or falling below these values.
10 The periodic limitations, see start-up (Section 6.10.1, Page 58 ff.), must be observed.
11 Benchmark for setting on external oil pressure regulating valve $p_{oil} \leq p_c$ + 2.5 bar
12 If $p_{oil} = p_c$ there is a danger of compressor damage as there is no oil flow.
13 When starting the compressor the maximum value can be temporarily exceeded.

Process parameters			
Mesh size Oil	W_{oil}	max	15 µm (function oil) in open processes (gas compression) • $\beta_{(15)} \geq 200$ 25 µm (function oil) in closed processes • $\beta_{(25)} \geq 200$

Notice

Information on * pressure difference $p_c - p_0$:

► If the compressor is operated without oil pump, a check valve with referential suction pressure must be installed after the oil separator.

► For this a minimum pressure difference of 2.9 bar* for the switch value must be adhered to.

Ambient conditions	
Ambient temperature	**Value range / to be observed**
Start-up Compressor	+5 °C ... +45 °C **Notice** Requirements on the minimum ambient temperature to avoid compressor damage. ► The minimum ambient temperature of 5°C must be reached at least 12 hours before start-up of the compressor.
Compressor operation	-20 °C ... +45 °C

All of the following requirements must be observed!

Minimum suction overheating in compressor inlet: "wet" operation has to be avoided.

For π ≥ 8 gas vibration protection is required.

For CO_2 usage the use of a completely electrified oil pump for injection and function oil needs to be checked in all types depending on the operating conditions.

Due to the solubility of refrigerant in the oil following applies:

- for Ammonia:
  - **$t_e \geq t_{oil}$ + 5 K**;
  - **$t_e \geq t_{oil}$ + 10 K**, when using a PAG oil (solubility of the refrigerant in the oil).
- For R22, R134a, R404A, R407C, R410A, R507, CO_2, natural gas, hydrocarbon compounds:
  - **$t_e \geq t_{oil}$ + 10 K**, wherein solubility of the refrigerant in the oil.

→ **To determine the permitted difference between the discharge temperature (t_e) and oil intake temperature (t_{oil}), the set viscosity and the solubility diagram for the refrigerant-oil pair from the lubrication supplier need to be adhered to.**

Ensure that the oil viscosity is 7...70 cSt for the oil supply to bearings. Take into account the drop in viscosity due to refrigerant dissolved in the oil!

Limits for temperature differences will be considered in compressor selection programs.

The oil temperature at the compressor inlet must be at least 18°C, the oil must be preheated if necessary.

The rate of temperature change at compressor suction side should not exceed 0,1 K/s.

For individual cases outside the permitted speed coordination needs to made with the manufacturer.

p_c	Discharge pressure / condensing pressure	t_{0h}	Suction temperature (compressor inlet)
p_0	Suction pressure	t_e	Discharge temperature (compressor outlet)
Δp	Pressure difference (p_c - p_0)	t_c	Condensing temperature
π	Pressure ratio (p_c/p_0)	t_{oil}	oil inlet temperature into the compressor

Notes:

1. During tests of a certain application case, all the conditions specified in the table must be considered and adhered to.
2. Should the given limits not be adhered to in individual cases, the manufacturer needs to be consulted.
3. In addition to the operating limits stated in the tables, the applicable operating conditions of the compressor type in question must also be considered (e.g. start-up regime, oil pressure, oil quantity, etc.).
4. Economizer operation:
   - Design M: Depending on the refrigeration requirements, economiser operation takes place at a control slide position between 100% and approx. 70%.
   - Design S: Depending on the refrigeration requirements, economiser operation takes place in a defined speed-range.
5. When using **R134a** as a refrigerant and a**evaporating temperature > 60 °C** the manufacturer must be consulted.

6.10 Start-up, frame sizes C, D, E, G

6.10.1 Initial operation

Notice

General requirements for the initial start-up of the compressor

► Before initial operation, the compressor must be checked by a specialist.
► Check the turning direction of the drive motor when the coupling is removed.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Carry out a pressure test according to the Installation and Maintenance Manual.
► Carry out a vacuum test according to the Installation and Maintenance Manual.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that safe supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

1. **Position of the Vi-slide / capacity slide in starting position**

   Design "S":

   - Before starting the driving motor:
     - Single compressor:

       The solenoid valves Y5 and Y6 will actuated and open.
     - DUO-Pack / MULTI-Pack, without oil pump:

       The solenoid valve Y6 will actuated and opens.
   - Starting the driving motor.
     - With starting the drive motor solenoid valve Y6 is actuated and remain opened, solenoid valve Y5 is deactivated and remain closed.
   - The driving motor moves up to start speed.
   - 20 seconds after reaching the start speed, releasing automatic Vi-adjustment.
   - The solenoid valve Y7 will actuated and closes.

   Design "M":

- **Before starting** the driving motor:
  - Single compressor:

    Vi-fixed: Actuation of the solenoid valves Y2 and Y4,

    Vi-variable: Actuation of the solenoid valves Y2, Y4, Y5 and Y6,

    Vi-fixed: Execution "B": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

    Vi-fixed: application "SWING": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,
  - DUO-Pack / MULTI-Pack, without oil pump:

    Vi-fixed: Actuation of the solenoid valve Y4,

    Vi-variable: Actuation of the solenoid valves Y4 and Y5,
  - DUO-Pack / MULTI-Pack, with oil pump:

    Vi-fixed: Actuation of the solenoid valve Y2,

    Vi-variable: Actuation of the solenoid valves Y2 and Y5,

    Vi-fixed: Execution "B": Actuation of the solenoid valves Y2 and Y3,

    Vi-fixed: application "SWING": Actuation of the solenoid valves Y2 and Y3,

  The valves are actuated in such a way that pressure compensation takes place at the piston of the control slide and the built-in spring can move the control slide into the MIN position.
- At start-up the current signal from the position indicator of the control slide, as specified on the position indicator must be:
  - 4... 5 mA (0%...6%).
- If after 180 sec. the above-mentioned current signal is not reached, the starting condition is extended to a current signal of:
  - 15 mA (0%...70%).
- **With start**of the drive motor, remain activated:
  - Vi-fixed: Solenoid valve Y2,
  - Vi-variable: Solenoid valves Y2 and Y5,
  - Vi-fixed, design "B": Solenoid valves Y2 and Y3,

  All other solenoids will deactivated with start of the drive motor and get closed.
  - Starting the external oil pump, if installed.
  - The solenoid valve Y7 will actuated and closes.

2. **Oil pressure**
   - For oil pressure see data sheet Section 6.9, Page 55.
3. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18°C (refer Section 6.9, Page 55).

     In the start-up phase, the oil viscosity may also briefly exceed the maximum permissible value of 70 cSt.

4. **Limiting time periods**

- Operation without oil pump:
  - Within the first 20 seconds after starting the drive motor, the oil pressure monitor must be ignored.
  - At the end of the 20 seconds, a differential pressure of "p_{oil} - p_0" > 0.5 bar must be maintained for the next 120 seconds.
    → The compressor must be switched off if, during the 120 seconds, the differential pressure "p_{oil} - p_0" is < 0.5 bar" for more than 20 seconds.
  - After the 120 seconds, the differential pressure must be "p_{oil} - p_0" > 2 bar.
    → The compressor must be switched off if the differential pressure "p_{oil} - p_0" is < 2.0 bar" for more than 20 seconds.
- Operation with oil pump:
  - Within 15 seconds after the drive motor has started, oil pressure must be $p_{oil} > p_0 + 2$ bar **and** $p_{oil} \geq p + 0{,}5$ bar. (p = pressure at the discharge side of the compressor; p_0 = suction pressure)

STOP CONDITIONS FOR COMPRESSORS OF THE M SERIES

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

With stop of the compressor motor, deactivate solenoid valve Y7.

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

Setting the discharge temperature

For adopting the discharge temperature to the operating conditions agreed in the project, the amount of injection oil injected into the compressor can be changed.

The requirements for this are:

- the compressor operates in the operating conditions agreed in the project (suction pressure, discharge pressure).
- the compressor operates in the maximum speed agreed in the project.
- the capacity control of the compressor is set to 100%power.
- or / and the variable Vi is set in the Vi-adjustment.

change the amount of injection oil injected by opening or closing the control valve: or in the supply line to the connection

- on connection B (Page 37)

or

- or in the supply line to connection B (Page 38).

Due to the inertia of the overall system, the change of the injected amount of oil must be carried out in small steps and with a holding time.

6.10.2 Start-up after long standstill period

Notice

General information on the safe start-up.

► Before start-up after long standstill periods, the compressor must be checked by instructed operating personnel.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

1. **Position of the Vi-slide / capacity slide in starting position**

Design "S":

- Before starting the driving motor:
  - Single compressor:

    The solenoid valves Y5 and Y6 will actuated and open.
  - DUO-Pack / MULTI-Pack, without oil pump:

    The solenoid valve Y6 will actuated and opens.
- Starting the driving motor.
  - With starting the drive motor solenoid valve Y6 is actuated and remain opened, solenoid valve Y5 is deactivated and remain closed.
- The driving motor moves up to start speed.
- 20 seconds after reaching the start speed, releasing automatic Vi-adjustment.
- The solenoid valve Y7 will actuated and closes.

Design "M":

- **Before starting** the driving motor:
  - Single compressor:

    Vi-fixed: Actuation of the solenoid valves Y2 and Y4,

Vi-variable: Actuation of the solenoid valves Y2, Y4, Y5 and Y6,

Vi-fixed: Execution "B": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

Vi-fixed: application "SWING": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

- DUO-Pack / MULTI-Pack, without oil pump:

  Vi-fixed: Actuation of the solenoid valve Y4,

  Vi-variable: Actuation of the solenoid valves Y4 and Y5,

- DUO-Pack / MULTI-Pack, with oil pump:

  Vi-fixed: Actuation of the solenoid valve Y2,

  Vi-variable: Actuation of the solenoid valves Y2 and Y5,

  Vi-fixed: Execution "B": Actuation of the solenoid valves Y2 and Y3,

  Vi-fixed: application "SWING": Actuation of the solenoid valves Y2 and Y3,

  The valves are actuated in such a way that pressure compensation takes place at the piston of the control slide and the built-in spring can move the control slide into the MIN position.

- At start-up the current signal from the position indicator of the control slide, as specified on the position indicator must be:
  - 4... 5 mA (0%...6%).
- If after 180 sec. the above-mentioned current signal is not reached, the starting condition is extended to a current signal of:
  - 15 mA (0%...70%).
- **With start**of the drive motor, remain activated:
  - Vi-fixed: Solenoid valve Y2,
  - Vi-variable: Solenoid valves Y2 and Y5,
  - Vi-fixed, design "B": Solenoid valves Y2 and Y3,

  All other solenoids will deactivated with start of the drive motor and get closed.
  - Starting the external oil pump, if installed.
  - The solenoid valve Y7 will actuated and closes.

2. **Oil pressure**
   - For oil pressure see data sheet Section 6.9, Page 55.
3. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18°C (refer Section 6.9, Page 55).

     In the start-up phase, the oil viscosity may also briefly exceed the maximum permissible value of 70 cSt.
4. **Limiting time periods**
   - Operation without oil pump:

- Within the first 20 seconds after starting the drive motor, the oil pressure monitor must be ignored.
- At the end of the 20 seconds, a differential pressure of "p_{oil} - p_0" > 0.5 bar must be maintained for the next 120 seconds.

  → The compressor must be switched off if, during the 120 seconds, the differential pressure "p_{oil} - p_0" is < 0.5 bar" for more than 20 seconds.
- After the 120 seconds, the differential pressure must be "p_{oil} - p_0 " > 2 bar.

  → The compressor must be switched off if the differential pressure "p_{oil} - p_0" is < 2.0 bar" for more than 20 seconds.

• Operation with oil pump:
- Within 15 seconds after the drive motor has started, oil pressure must be p_{oil} > p_0 + 2 bar **and** p_{oil} ≥ p + 0,5 bar. (p = pressure at the discharge side of the compressor; p_0 = suction pressure)

STOP CONDITIONS FOR COMPRESSORS OF THE M SERIES

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

With stop of the compressor motor, deactivate solenoid valve Y7.

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

6.10.3 Automatic mode (Start-Stop mode)

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

Notice

General information on the safe start-up.

► Before start-up after long standstill periods, the compressor must be checked by instructed operating personnel.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

1. **Position of the Vi-slide / capacity slide in starting position**

   Design "S":

   - Before starting the drive motor: solenoid valves Y5 and Y6 will be energized and remain opened.
   - Starting the driving motor.
     - With starting the drive motor solenoid valve Y6 is actuated and remain opened, solenoid valve Y5 is deactivated and remain closed.
   - The driving motor moves up to start speed.
   - 20 seconds after reaching the start speed, releasing automatic Vi-adjustment.

   Design "M":

   - **Before starting** the driving motor:
     - Vi-fixed: Actuation of the solenoid valves Y2 and Y4,
     - Vi-variable: Actuation of the solenoid valves Y2, Y4, Y5 and Y6,
     - Vi-fixed: Execution "B": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,
     - Vi-fixed: application "SWING": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

     that a pressure adjusting can occur at the piston of the control slide and the built-in spring can move the control slide into the MIN position.

- At start-up the current signal from the position indicator of the control slide, as specified on the position indicator must be:
  - 4... 5 (0%...6%) mA.
- If after 180 sec. the above-mentioned current signal is not reached, the starting condition is extended to a current signal of:
  - 8 mA.
- **With start**of the drive motor, remain activated:
  - Vi-fixed: Solenoid valve Y2,
  - Vi-variable: Solenoid valves Y2 and Y5,
  - Vi-fixed, design "B": Solenoid valves Y2 and Y3,

  All other solenoids will deactivated with start of the drive motor and get closed.

  Starting the external oil pump, if installed.
  - Activation of solenoid valve Y7, closing the valve solenoid valve

2. **Oil pressure**
   - For oil pressure see data sheet Section 6.9, Page 55.
3. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18°C (refer Section 6.9, Page 55).

     In the start-up phase, the oil viscosity may also briefly exceed the maximum permissible value of 70 cSt.
4. **Limiting time periods**
   - Operation without oil pump:
     - Within the first 20 seconds after starting the drive motor, the oil pressure monitor must be ignored.
     - At the end of the 20 seconds, a differential pressure of "p_{oil} - p_0" > 0.5 bar must be maintained for the next 120 seconds.

       → The compressor must be switched off if, during the 120 seconds, the differential pressure "p_{oil} - p_0" is < 0.5 bar" for more than 20 seconds.
     - After the 120 seconds, the differential pressure must be "p_{oil} - p_0 " > 2 bar.

       → The compressor must be switched off if the differential pressure "p_{oil} - p_0" is < 2.0 bar" for more than 20 seconds.
   - Operation with oil pump:
     - Within 15 seconds after the drive motor has started, oil pressure must be p_{oil} > p_0 + 2 bar **and**p_{oil} ≥ p + 0,5 bar. (p = pressure at the discharge side of the compressor; p_0 = suction pressure)

STOP CONDITIONS FOR COMPRESSORS OF THE M SERIES

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

With stop of the compressor motor, deactivate solenoid valve Y7.

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

7 M series; frame sizes H, L, M, N

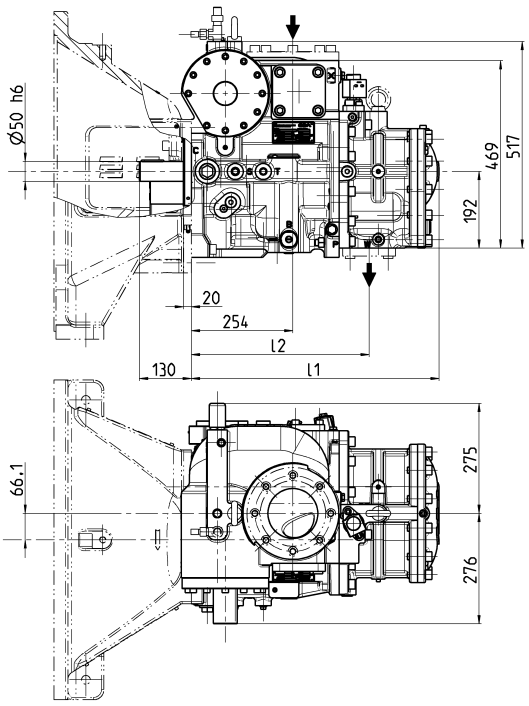
7.1 Nominal data; frame sizes H, L, M, N

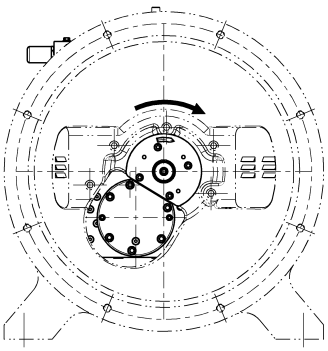
		Compressor frame size							
		H		L		M		N	
		Style M	Style S	Style M	Style S	Style M	Style S	Style M	Style S
Suction volume flow at 2940 rpm	[m³/h]	471		544		708		870	
Number of teeth of rotors MR / FR	[-]	5 / 6							
Speed, max	[rpm]	4500							
Speed, min	[rpm]	1000							
Range of the capacity control, continuous		10% * ... 100%							
Vi variable		1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0	1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0	1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0	1.8...3.0 2.2...4.0 2.6...5.5	1.4...2.7 1.8...5.0
Vi - fixed		1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-	1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-	1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-	1.8 / 2.0 / 2.2 / 2.6 / 3.0 / 3.6 / 4.8 / 5.5	-
Weight without motor with / without coupling housing	[kg]	575 / 415		605 / 445		770 / 610		800 / 640	
Mass moment of inertia of the rotor pair	[kgm²]	0.109		0.128		0.223		0.272	
Max. drive power at 50 Hz / 60 Hz	[kW]	300 / 360 (28 bar)				300 / 360 (28 bar) 530 / 640 (52 bar)	300 / 360 (28 bar)	300 / 360 (28 bar) 530 / 640 (52 bar)	300 / 360 (28 bar)
Max. nominal torque	[Nm]	960 (28 bar)				960 (28 bar) 1700 (52 bar)	960 (28 bar)	960 (28 bar) 1700 (52 bar)	960 (28 bar)

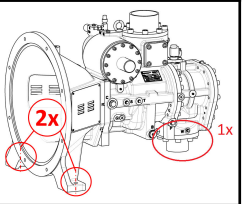
** This value may vary depending on the operating conditions.

7.2 Main dimensions; frame sizes H, L, M, N

Frame sizes H, L
Stand-alone installation with coupling housing







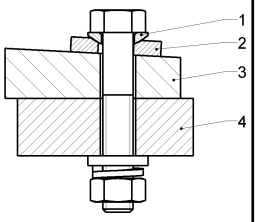
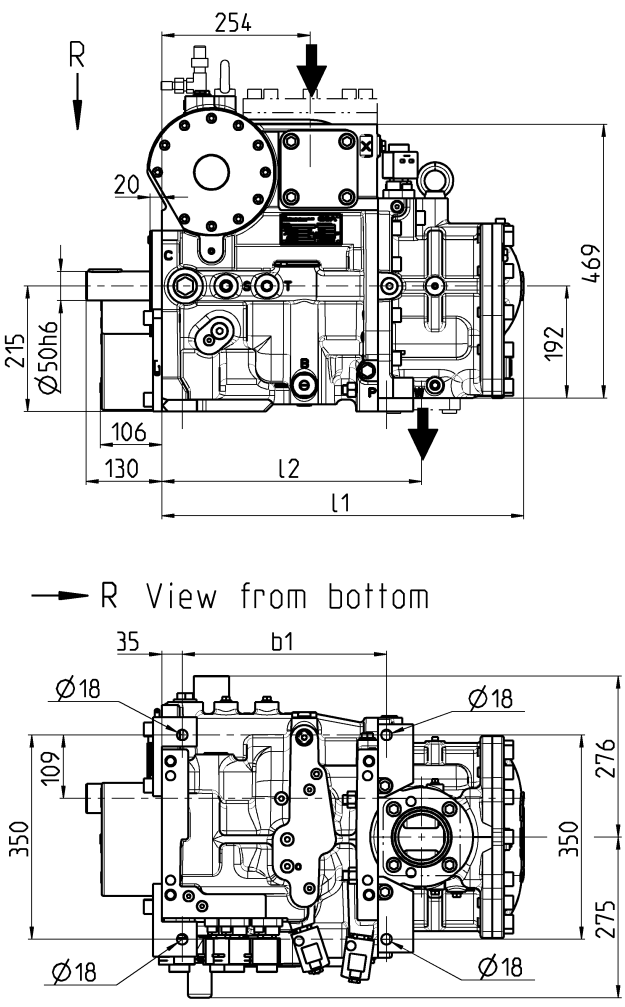


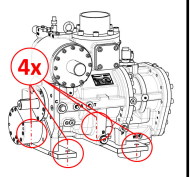
Fig.15

1	Spherical washer
2	Conical seat
3	Coupling housing
4	Screw Compressor Package

Main dimensions, connection dimensions Stand-alone installation with coupling housing			
Main dimensions		**Compressor <u>without</u> coupling housing and coupling**	
		Frame sizes H	**Frame sizes L**
l1 [mm]		620 (28 bar)	656
		670 (52 bar, 63 bar)	
l2 [mm]		445	481
Drive shaft diameter		50 h6	50 h6
Connection	Suction side	DN 125	DN 125
	Pressure side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. weight, max. (kg) with / without Coupling housing		575 / 415	605 / 445
The dimensions of the coupling housing can be found in Section 7.3, Page 76 and ff.			

Frame sizes H, L
Stand-alone installation with attachment strips





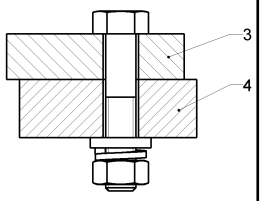
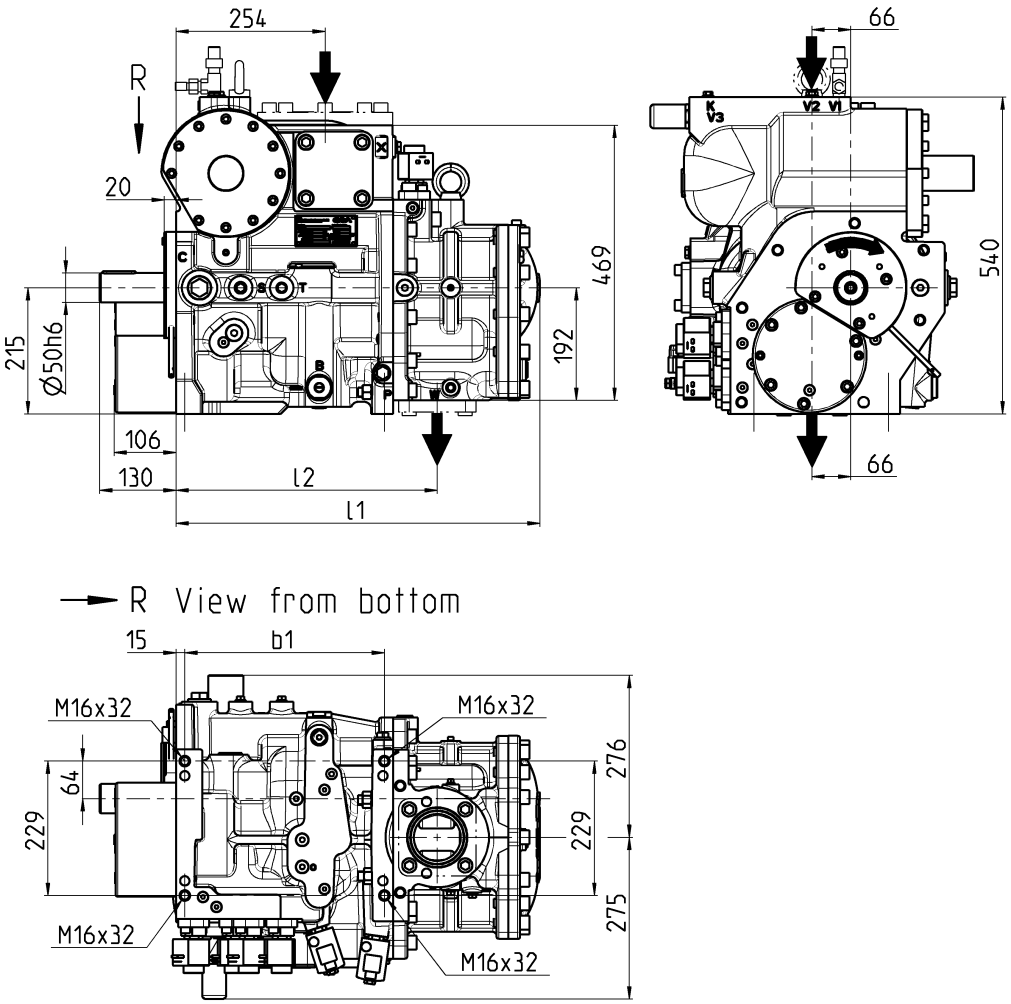


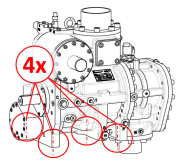
Fig.16

3	Attachment strip
4	Screw Compressor Package

Main dimensions, connection dimensions Stand-alone installation with attachment strips			
Main dimensions		**Compressor**	
		Frame sizes H	**Frame sizes L**
l1 [mm]		620 (28 bar)	656
		670 (52 bar, 63 bar)	
l2 [mm]		445	481
b1 [mm]		350	386
Drive shaft diameter		50 h6	50 h6
Connection	Suction side	DN 125	DN 125
	Pressure side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. weight, max. (kg)		420	450

Frame sizes H, L
Single setting





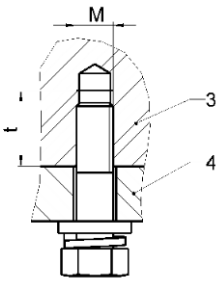
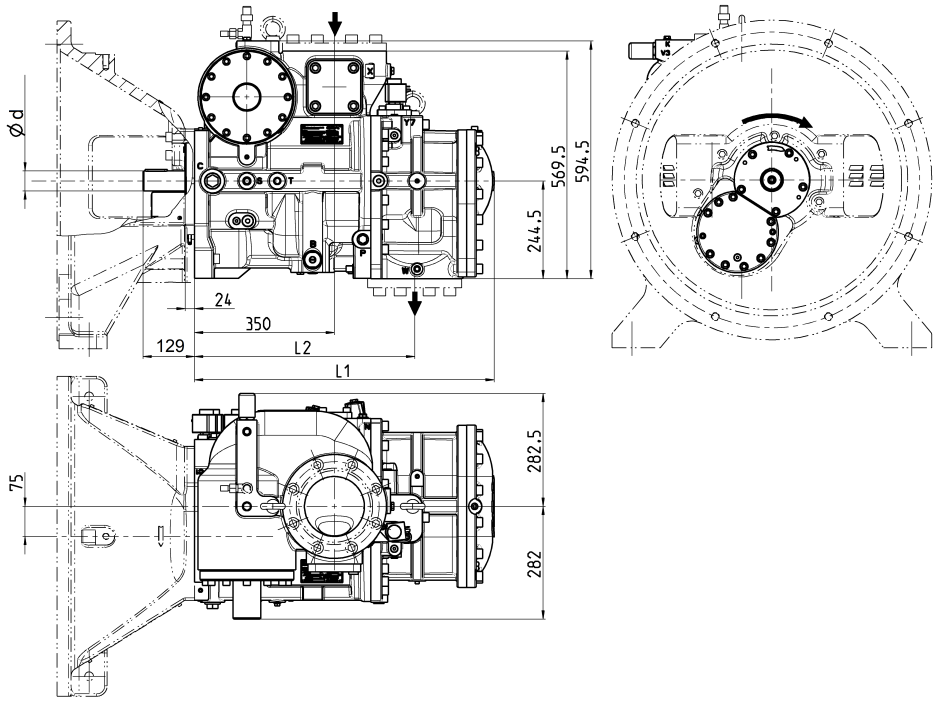


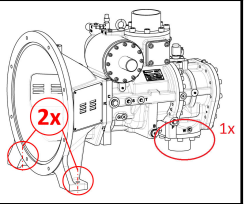
Fig.17

3	Compressor
4	Screw Compressor Package
M	M16
t	32 mm

Main dimensions, connection dimensions Single setting			
Main dimensions		**Compressor**	
		Frame sizes H	**Frame sizes L**
l1 [mm]		620 (28 bar)	656
		670 (52 bar, 63 bar)	
l2 [mm]		445	481
b1 [mm]		340	376
Drive shaft diameter		50 h6	50 h6
Connection	Suction side	DN 125	DN 125
	Pressure side	DN 80	DN 80
	Economizer	DN 40	DN 40
approx. weight, max. (kg)		415	445

Sizes M, N
Stand-alone installation with coupling housing





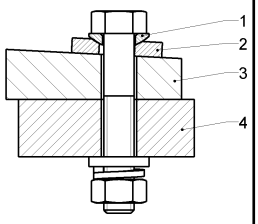
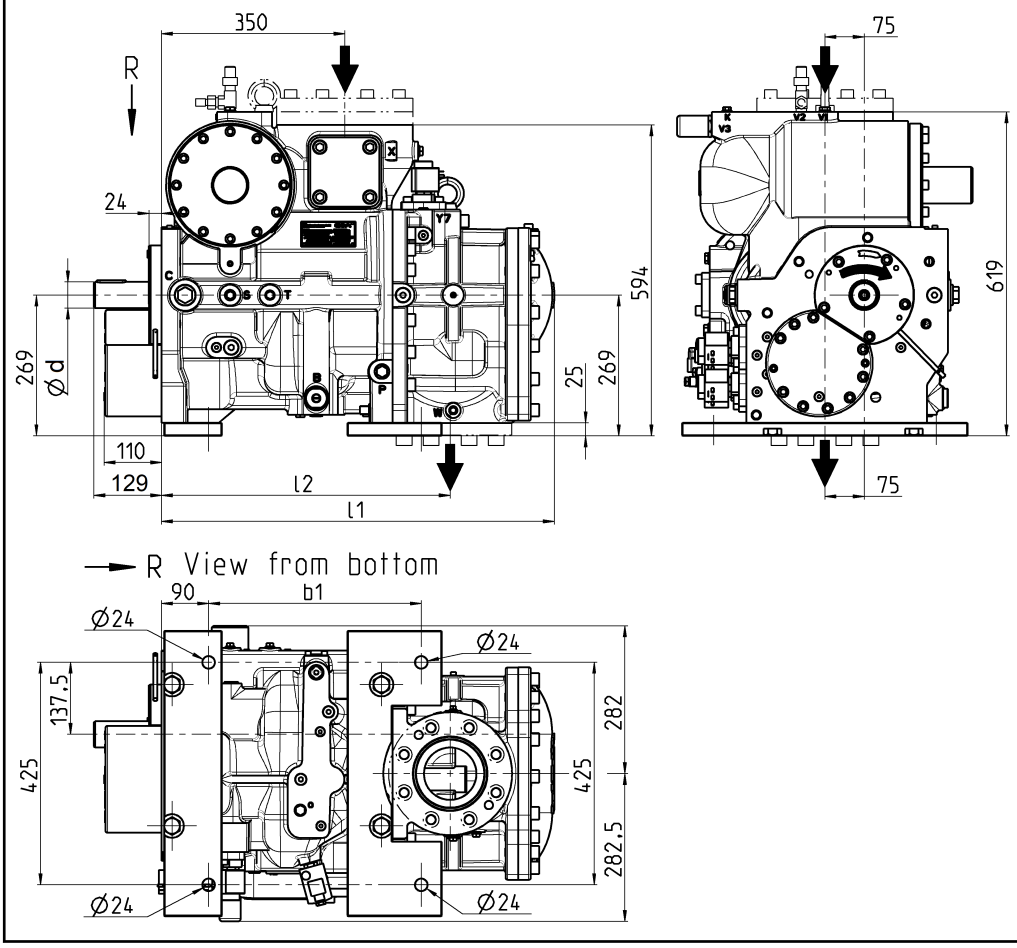


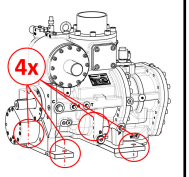
Fig.18

1	Spherical washer
2	Conical seat
3	Coupling housing
4	Screw Compressor Package

Main dimensions, connection dimensions Stand-alone installation with coupling housing			
Main dimensions		**Compressor <u>without</u> coupling housing and coupling**	
		Sizes M	**Sizes N**
l1 [mm]		750 (28 bar)	801 (28 bar)
		800 (52 bar, 63 bar)	851 (52 bar, 63 bar)
l2 [mm]		551	602
Drive shaft diameter		50 h6 (28 bar.g)	50 h6 (28 bar.g)
		60 h6 (52 bar, 63 bar)	60 h6 (52 bar, 63 bar)
Connection	Suction side	DN 150	DN 150
	Pressure side	DN 100	DN 100
	Economizer	DN 40	DN 40
approx. weight, max. (kg) with / without Coupling housing		770 / 610	800 / 640
The dimensions of the coupling housing can be found in Section 7.3, Page 76 and ff.			

Sizes M, N
Stand-alone installation with attachment strips





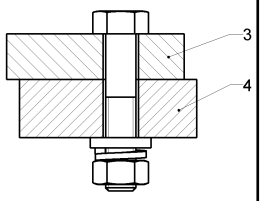
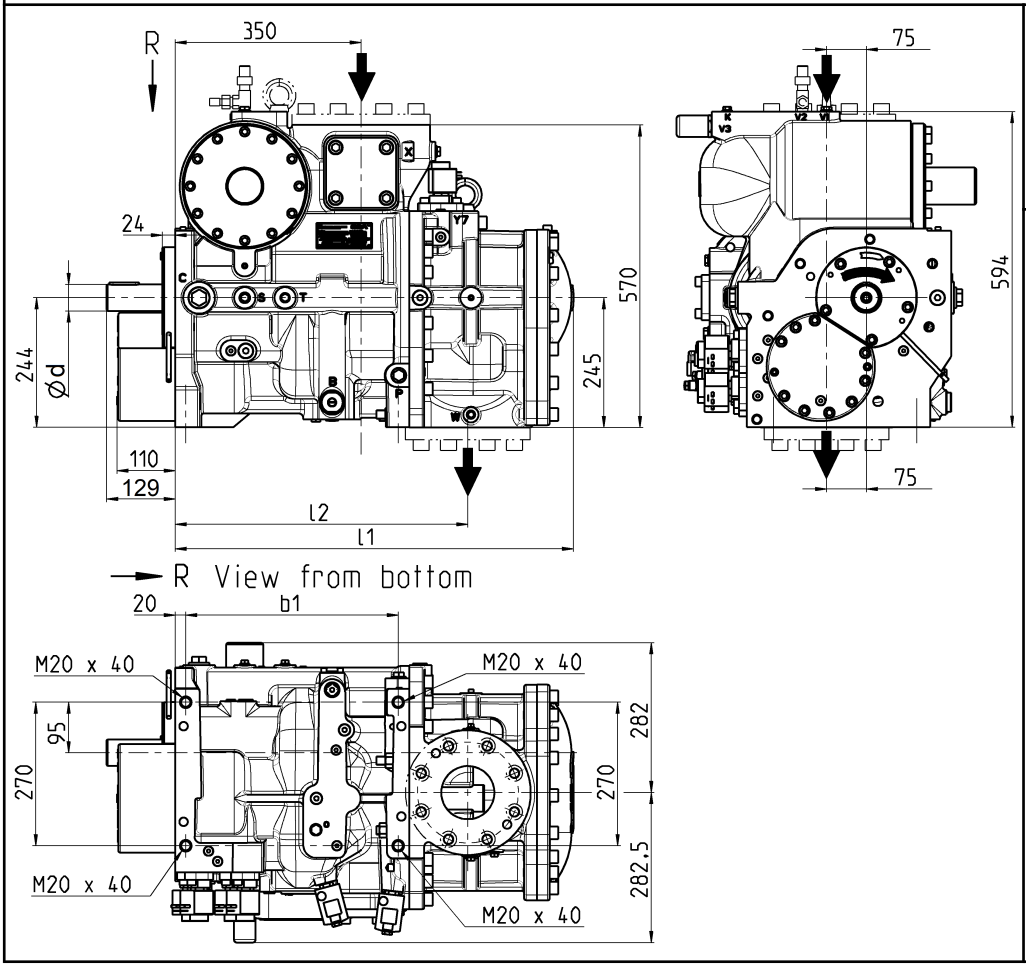


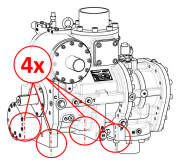
Fig.19

3	Attachment strip
4	Screw Compressor Package

Main dimensions, connection dimensions Stand-alone installation with attachment strips			
Main dimensions		**Compressor**	
		Sizes M	**Sizes N**
l1 [mm]		750 (28 bar)	801 (28 bar)
		800 (52 bar, 63 bar)	851 (52 bar, 63 bar)
l2 [mm]		551	602
b1 [mm]		406	457
Drive shaft diameter		50 h6 (28 bar.g)	50 h6 (28 bar.g)
		60 h6 (52 bar, 63 bar)	60 h6 (52 bar, 63 bar)
Connection	Suction side	DN 150	DN 150
	Pressure side	DN 100	DN 100
	Economizer	DN 40	DN 40
approx. weight, max. (kg)		615	645

Sizes M, N
Single setting





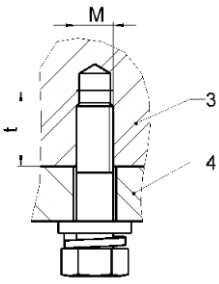


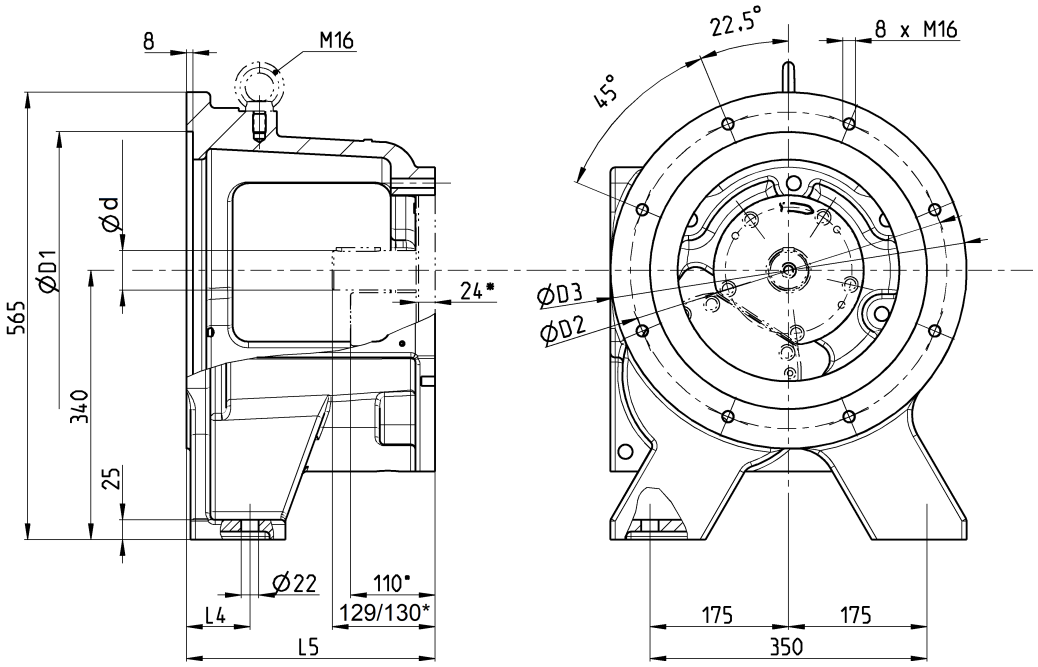
Fig.20

3	Compressor
4	Screw Compressor Package
M	M20
t	40 mm

Main dimensions, connection dimensions Single setting			
Main dimensions		**Compressor**	
		Sizes M	**Sizes N**
l1 [mm]		750 (28 bar)	801 (28 bar)
		800 (52 bar, 63 bar)	851 (52 bar, 63 bar)
l2 [mm]		551	602
b1 [mm]		400	451
Drive shaft diameter		50 h6 (28 bar.g)	50 h6 (28 bar.g)
		60 h6 (52 bar, 63 bar)	60 h6 (52 bar, 63 bar)
Connection	Suction side	DN 150	DN 150
	Pressure side	DN 100	DN 100
	Economizer	DN 40	DN 40
approx. weight, max. (kg)		610	640

7.3 Coupling housing
for compressor frame size H, L, M, N

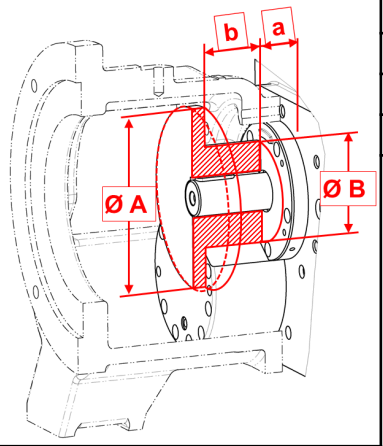
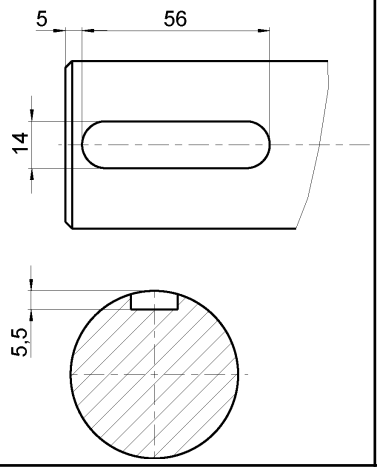
Coupling housing; frame size IEC 33; centring collar Ø 300 ; Ø 350



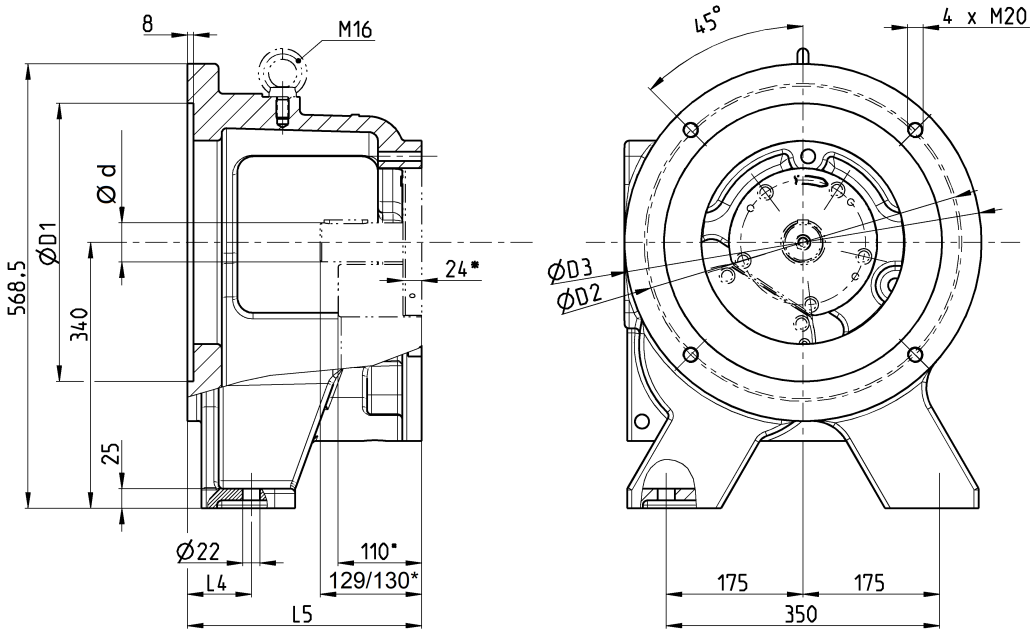
* == compressor dimensions

Coupling housing **Size IEC 33** **Centring collar Ø 300 ; Ø 350**		**Variant**		
		0819087	**0819088**	**0819089**
Centring collar diameter	D1	300	350	350
Pitch circle diameter of the motor mounting bolt	D2	350	400	400
Diameter of motor flange	D3	450	450	450
Distance between motor flange - frame mounting of the coupling housing	L4	80	80	110
Length of coupling housing	L5	314	314	344
Drive shaft diameter	d	50 h6 (28 bar.g)		
		60 h6 (52 bar, 63 bar)		
Mounting screws Coupling housing - aggregate frame		M20		
Maximum permissible torque on the motor flange due to motor weight		4420 Nm		
Maximum permissible torque on the motor flange due to motor tipping torque		1730 Nm		

Installation space for the coupling, compressor side

	Coupling housing **Size IEC 33** **Centring collar Ø 300 ; Ø 350**		**Compressor frame size**	
			H, L	**M, N**
	Hub flange diameter	Ø A	≤ 250 mm	
	Hub diameter	Ø B	≤ 110 mm	≤ 140 mm
	Mounting dimension	a	≥ 25 mm	≥ 30 mm
	Clearance	b	≥ 86 mm	≥ 85 mm
Shaft end of the compressor 				

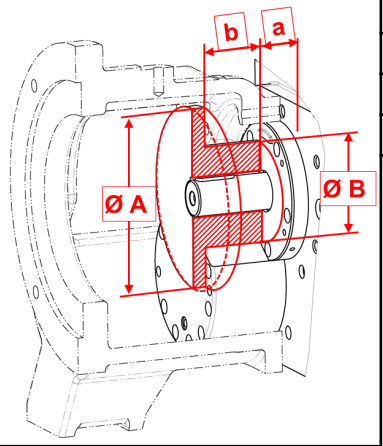
Coupling housing; frame size NEMA 33; centring collar Ø 355.6 ; Ø 279.4



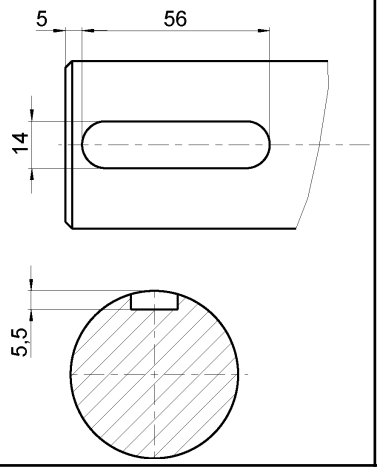
* == compressor dimensions

Coupling housing **Size NEMA 33** **Centring collar Ø 355.6 ; Ø 279.4**		**Variant**	
		0819095	**0819096**
Centring collar diameter	D1	355.6	279.4
Pitch circle diameter of the motor mounting bolt	D2	406.4	317.5
Diameter of motor flange	D3	450	450
Distance between motor flange - frame mounting of the coupling housing	L4	82	70
Length of coupling housing	L5	300	288
Drive shaft diameter	d	50 h6 (28 bar.g)	
		60 h6 (52 bar, 63 bar)	
Mounting screws Coupling housing - aggregate frame		M20	
Maximum permissible torque on the motor flange due to motor weight		8820 Nm	
Maximum permissible torque on the motor flange due to motor tipping torque		1730 Nm	

Installation space for the coupling, compressor side

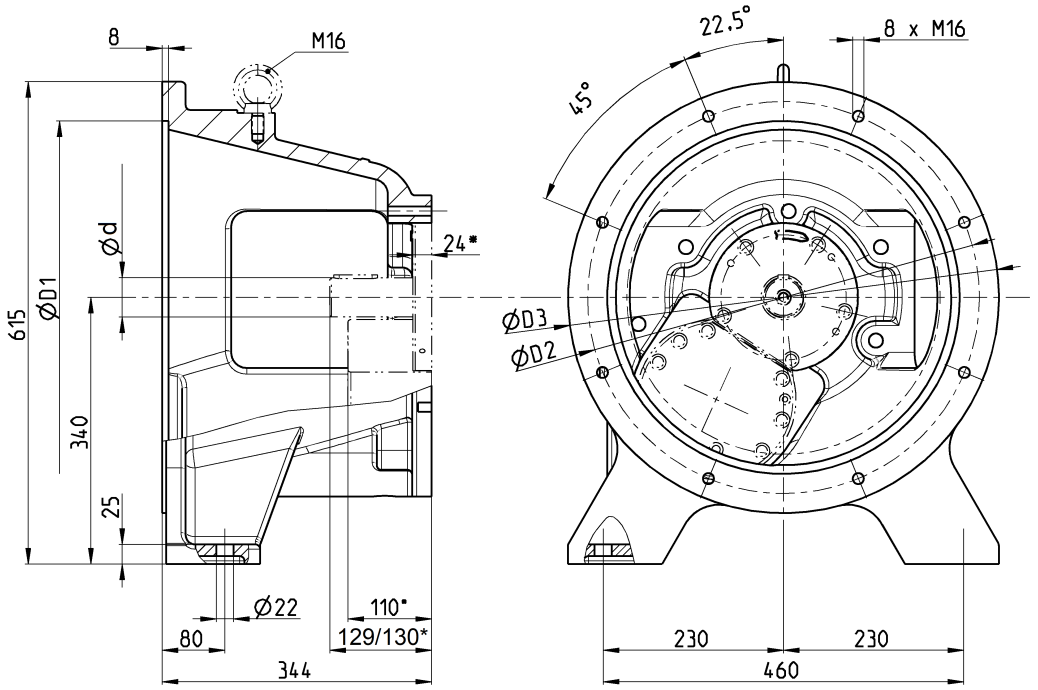


Shaft end of the compressor



Coupling housing Size NEMA 33 Centring collar Ø 355.6; Ø 279.4		Compressor frame size	
		H, L	M, N
Hub flange diameter	Ø A	≤ 250 mm	
Hub diameter	Ø B	≤ 110 mm	≤ 140 mm
Mounting dimension	a	≥ 25 mm	≥ 30 mm
Clearance	b	≥ 86 mm	≥ 85 mm

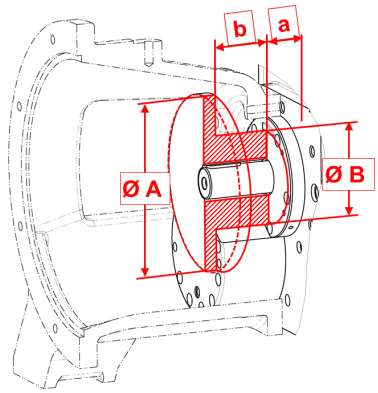
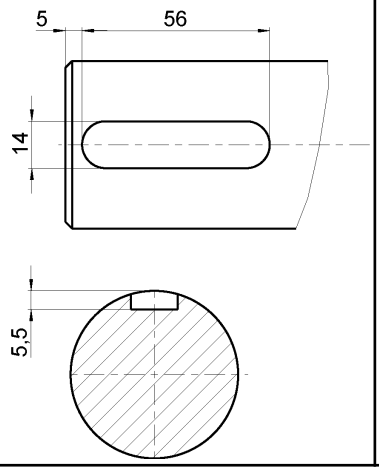
Coupling housing; frame size IEC 34; centring collar Ø 450



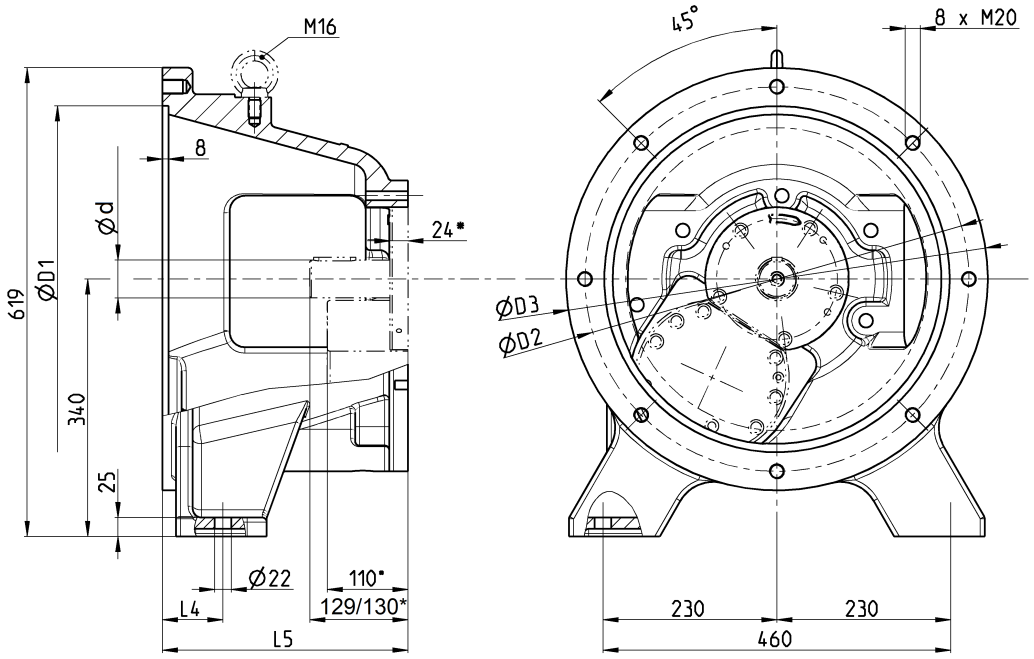
* == compressor dimensions

Coupling housing **Size IEC 34** **Centring collar Ø 450**		**Variant**
		0819091
Centring collar diameter	D1	450
Pitch circle diameter of the motor mounting bolt	D2	500
Diameter of motor flange	D3	550
Drive shaft diameter	d	50 h6 (28 bar.g)
		60 h6 (52 bar, 63 bar)
Mounting screws Coupling housing - aggregate frame		M20
Maximum permissible torque on the motor flange due to motor weight		8820 Nm
Maximum permissible torque on the motor flange due to motor tipping torque		1730 Nm

Installation space for the coupling, compressor side

	Coupling housing **Size IEC 34** **Centring collar Ø 450**		**Compressor frame size**	
			H, L	**M, N**
	Hub flange diameter	Ø A	≤ 280 mm	
	Hub diameter	Ø B	≤ 110 mm	≤ 140 mm
	Mounting dimension	a	≥ 25 mm	≥ 30 mm
	Clearance	b	≥ 86 mm	≥ 85 mm
Shaft end of the compressor 				

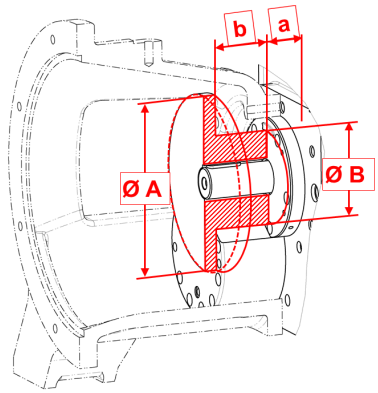
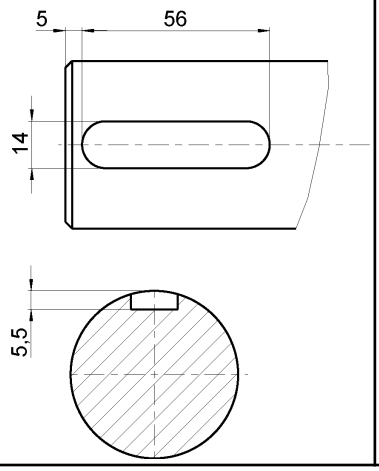
Coupling housing; frame size NEMA 34; centring collar Ø 457.2



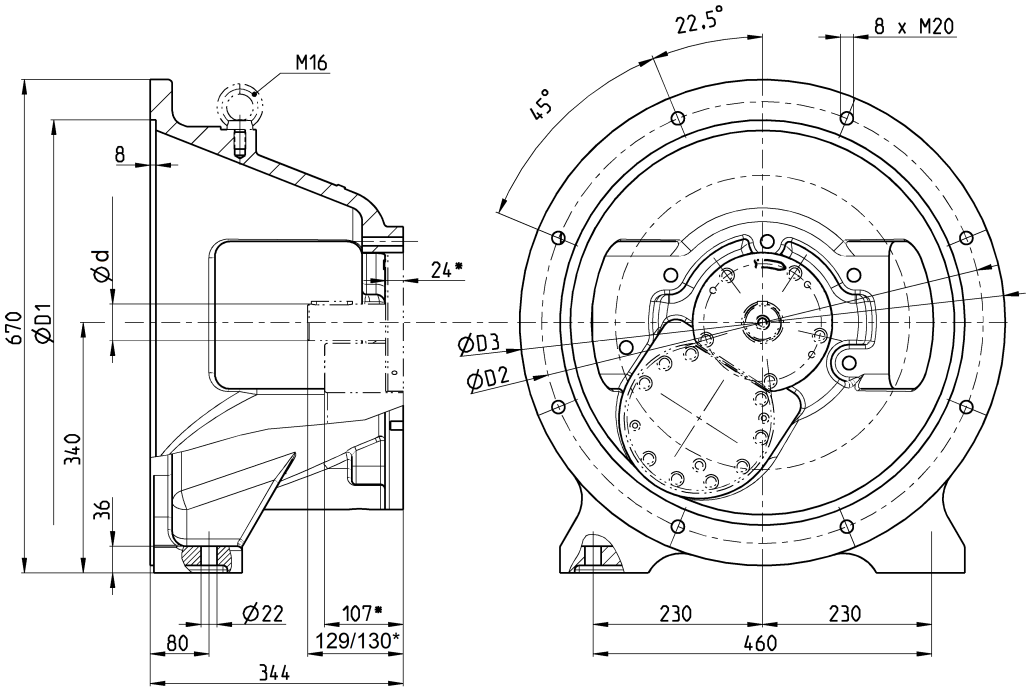
* == compressor dimensions

Coupling housing **Size NEMA 34** **Centring collar Ø 457.2**		**Variant**	
		0819098	**0819099**
Centring collar diameter	D1	457.2	457.2
Pitch circle diameter of the motor mounting bolt	D2	508	508
Diameter of motor flange	D3	550	550
Distance between motor flange - frame mounting of the coupling housing	L4	80	67
Length of coupling housing	L5	325	312
Drive shaft diameter	d	50 h6 (28 bar.g)	
		60 h6 (52 bar, 63 bar)	
Mounting screws Coupling housing - aggregate frame		M20	
Maximum permissible torque on the motor flange due to motor weight		8820 Nm	
Maximum permissible torque on the motor flange due to motor tipping torque		1730 Nm	

Installation space for the coupling, compressor side

	Coupling housing **Size NEMA 34** **Centring collar Ø 457.2**		**Compressor frame size**	
			H, L	**M, N**
	Hub flange diameter	Ø A	≤ 280 mm	
	Hub diameter	Ø B	≤ 110 mm	≤ 140 mm
	Mounting dimension	a	≥ 25 mm	≥ 30 mm
	Clearance	b	≥ 86 mm	≥ 85 mm
Shaft end of the compressor 				

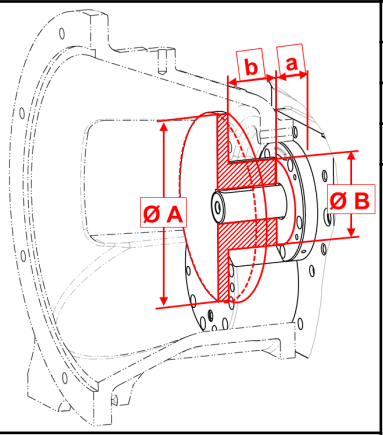
Coupling housing; frame size IEC 35; centring collar Ø 550



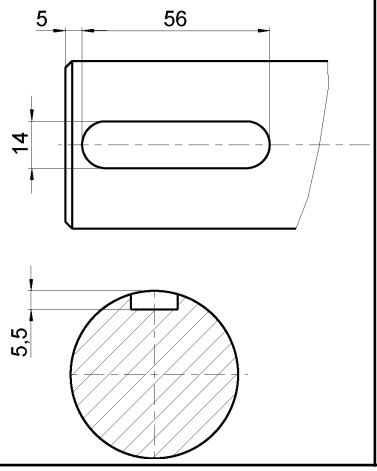
* == compressor dimensions

Coupling housing **Size IEC 35** **Centring collar Ø 550**		**Variant**
		0818480
Centring collar diameter	D1	550
Pitch circle diameter of the motor mounting bolt	D2	600
Diameter of motor flange	D3	660
Drive shaft diameter	d	50 h6 (28 bar.g)
		60 h6 (52 bar, 63 bar)
Mounting screws Coupling housing - aggregate frame		M20
Maximum permissible torque on the motor flange due to motor weight		8820 Nm
Maximum permissible torque on the motor flange due to motor tipping torque		1140 Nm

Installation space for the coupling, compressor side

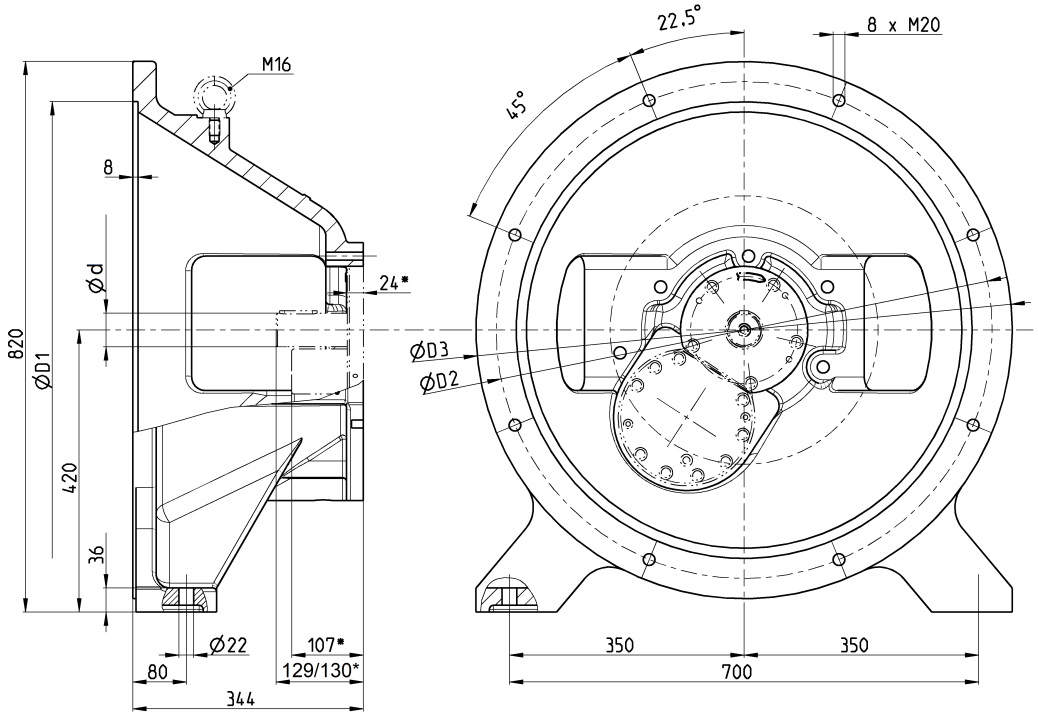


Shaft end of the compressor



Coupling housing Size IEC 35 Centring collar Ø 550		Compressor frame size	
		H, L	M, N
Hub flange diameter	Ø A	≤ 300 mm	
Hub diameter	Ø B	≤ 110 mm	≤ 140 mm
Mounting dimension	a	≥ 25 mm	≥ 30 mm
Clearance	b	≥ 86 mm	≥ 85 mm

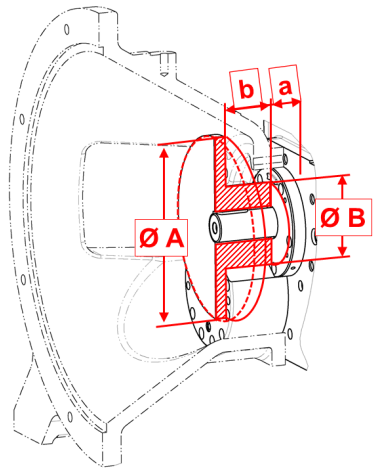
Coupling housing; frame size IEC 36; centring collar Ø 680



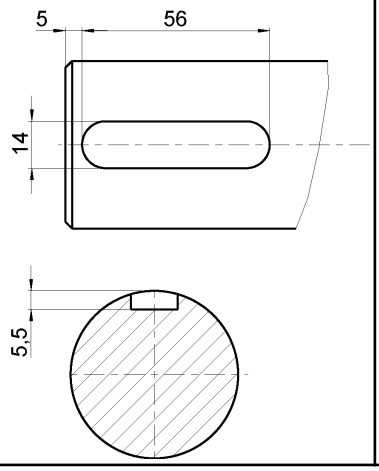
* == compressor dimensions

Coupling housing **Size IEC 36** **Centring collar Ø 680**		**Variant**
		0819093
Centring collar diameter	D1	680
Pitch circle diameter of the motor mounting bolt	D2	740
Diameter of motor flange	D3	800
Drive shaft diameter	d	50 h6 (28 bar.g)
		60 h6 (52 bar, 63 bar)
Mounting screws Coupling housing - aggregate frame		M20
Maximum permissible torque on the motor flange due to motor weight		8820 Nm
Maximum permissible torque on the motor flange due to motor tipping torque		1730 Nm

Installation space for the coupling, compressor side



Shaft end of the compressor



Coupling housing Size IEC 36 Centring collar Ø 680		Compressor frame size	
		H, L	M, N
Hub flange diameter	Ø A	≤ 320 mm	
Hub diameter	Ø B	≤ 110 mm	≤ 140 mm
Mounting dimension	a	≥ 25 mm	≥ 30 mm
Clearance	b	≥ 86 mm	≥ 85 mm

7.4 Connections; frame sizes H, L, M, N

P+I DIAGRAMM

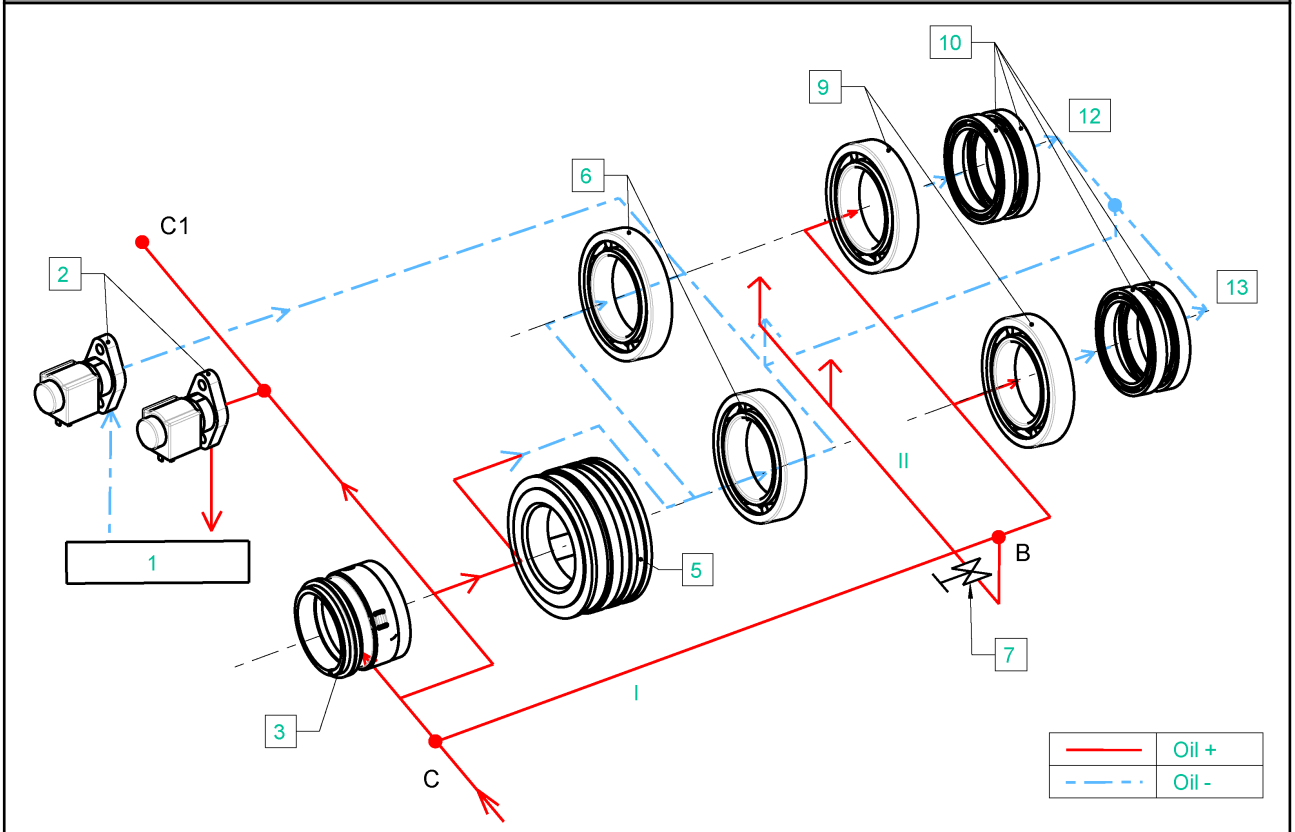
Notice

Application information!

► The nameplate of each compressor is marked with the pertaining P+I number of the screw compressor.
► The P+I diagram applies to the screw compressor only.
► The P+I diagram for the screw compressor only shows the connecting conditions to the screw compressor package.
► The P+I diagram of the screw compressor does not consider the piping scheme and the safety devices of the screw compressor package.
► The specified oil supply diagram of the compressor is part of the documentation and will be supplied with the compressor.

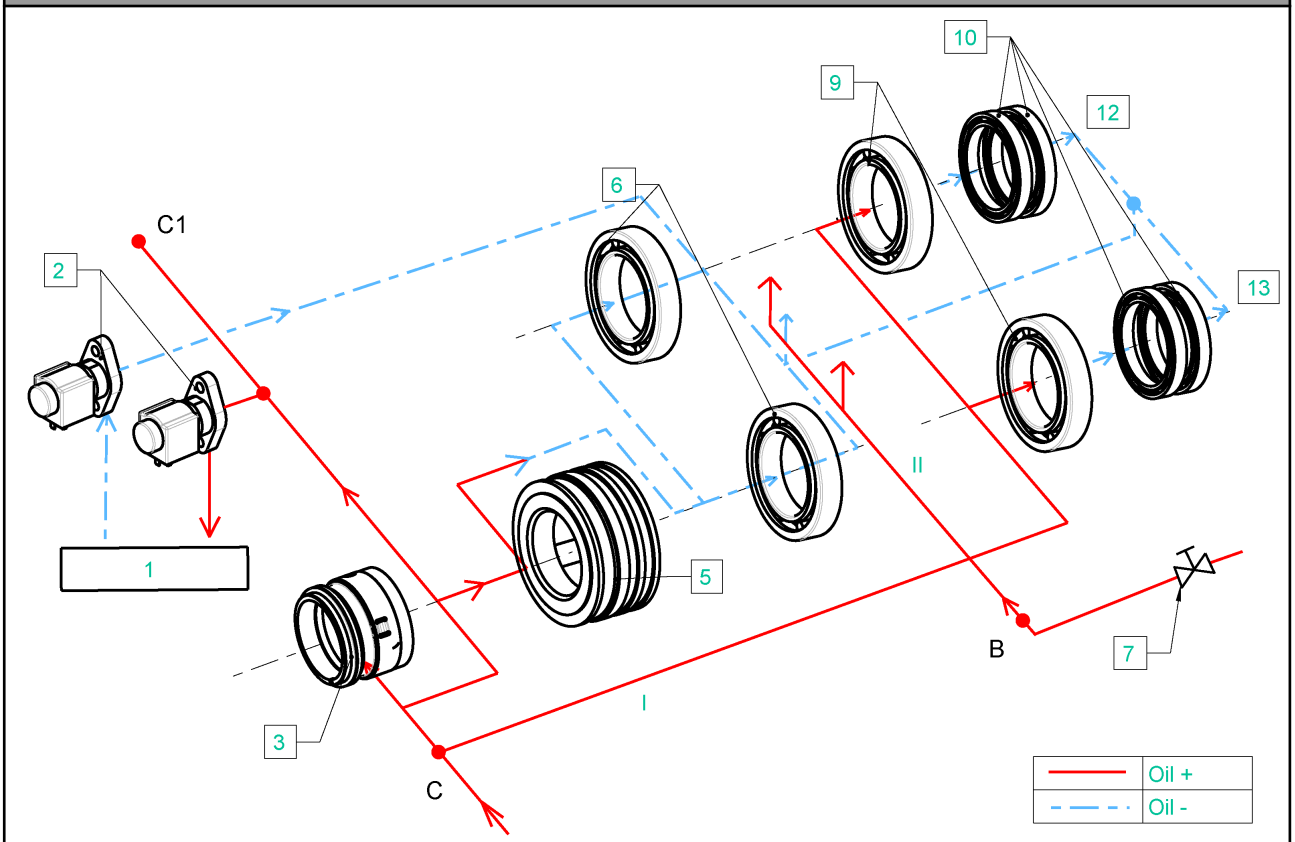
P+I diagrams are available for connecting the package oil circuit to the compressor, which will be determined based on the usage of the machines and have special labels.

Central oil supply for functional oil and injection oil



Oil +	Oil feed; oil flow inside the compressor (high pressure)	1	Capacity control/ Vi adjustment
Oil -	Oil flow inside the compressor (low pressure)	2	Solenoid valves; Capacity control/ Vi adjustment
		3	Shaft Seal
C / C1	Oil supply; functional oil, injection oil	5	Balance piston
B, 7	Injection oil quantity adjustment	6	Radial bearing of the rotors (suction side)
		7	Injection oil quantity adjustment
I	Oil channel: functional oil discharge side, injection oil	9	Radial bearing of the rotors (discharge side)
II	Oil channel: injection oil to working chamber	10	Thrust bearing of the rotors
		12, 13	Oil return of the bearing oil of the discharge side in the direction of the working chamber

Separate oil supply for functional oil and injection oil



Oil +	Oil feed; oil flow inside the compressor (high pressure)	1	Capacity control/ Vi adjustment
Oil -	Oil flow inside the compressor (low pressure)	2	Solenoid valves; Capacity control/ Vi adjustment
		3	Shaft Seal
C / C1	Oil feed; functional oil	5	Balance piston
B	Oil feed; injection oil	6	Radial bearing of the rotors (suction side)
		7	Injection oil quantity adjustment
I	Oil channel: functional oil discharge side, injection oil	9	Radial bearing of the rotors (discharge side)
II	Oil channel: injection oil to working chamber	10	Thrust bearing of the rotors
		12, 13	Oil return of the bearing oil of the discharge side in the direction of the working chamber

CONNECTIONS

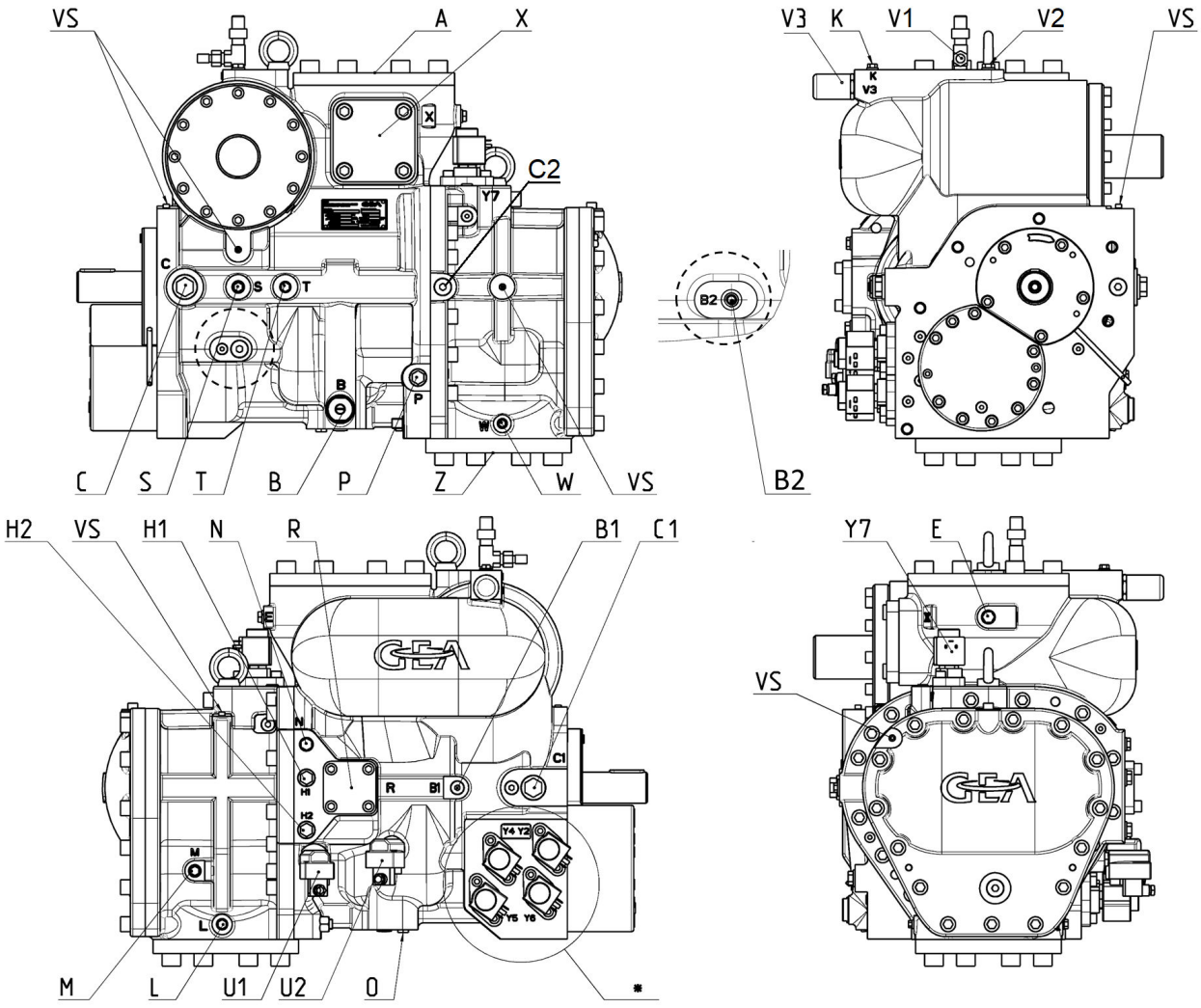


Fig.21: Connections, example: type, M, Vi-variable

*	Solenoid valves, description, function and arrangement depending on compressor-design and -execution, see Page 95.

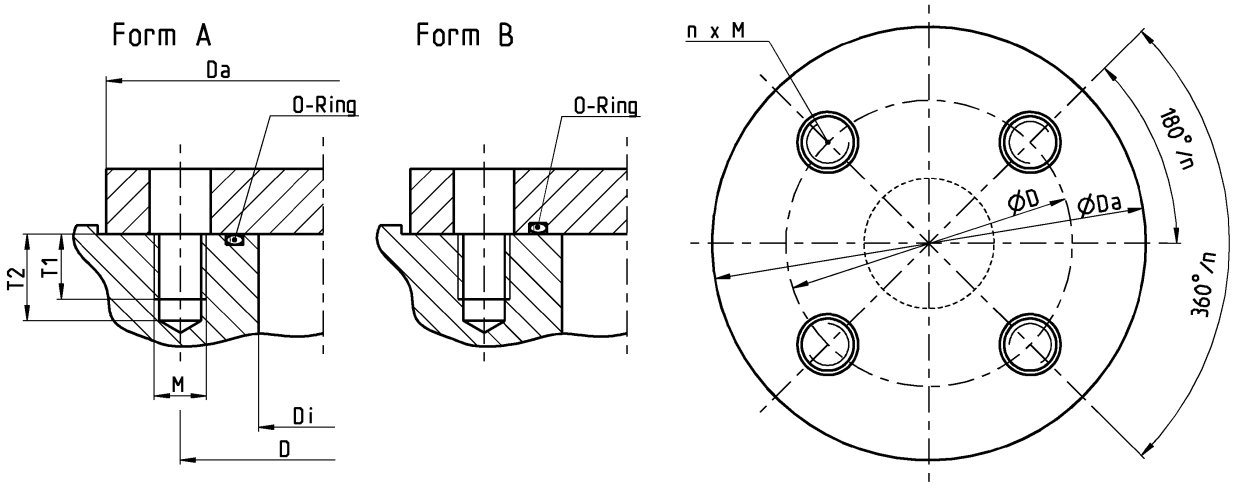
PIPE CONNECTIONS / THREADS			
Connection	**Purpose**	**Nominal diameter/thread**	
		Compressor frame size	
		H, L	**M, N**
A	Suction nozzle	DN 125 *	DN 150 *
B	Injection oil quantity adjustment Optional: external injection oil supply	G ¾"	
B1	Additional oil injection	M16 x 1.5	
B2	Additional oil injection, only design "S"	M16 x 1.5	
C	Function- and injection oil	M33 x 2	
C1	Function- and injection oil Optional to connection C	M33 x 2	
	Optional: external oil supply for solenoid valve, when function- and injection oil via connection C	M16 x 1.5	
C2	Option: function oil bearings discharge housing	M22 x 1.5	
E	Measuring suction temperature	M12 x 1.5	
H1	Refrigerant injection (LP)	M16 x 1.5	M22 x 1.5
H2	Refrigerant injection (HP)	M16 x 1.5	M22 x 1.5
K	Measuring suction pressure	G ¼	
L	Measuring discharge temperature	M12 x 1.5	
M	Measuring discharge pressure	G ¼	
N	Oil return from oil separator	M16 x 1.5	
O	Oil drain plug	M16 x 1.5	
P	Gas vibration protection	M16 x 1.5	M22 x 1.5
R	Economizer	DN 40 *	
S	Measuring oil pressure	G ¼	
T	Measuring oil temperature	M12 x 1.5	
V1, V2	Service port suction side, Vent valve	M16 x 1.5	
V3	Integrated service valve, for suction side check valve	M24 x 1.5	
VS	Vibration sensor connection	¼ " -28 UNF x 10	
W	Service port discharge side	M10 x 1	
X	Overflow valve connection	Ø80 *	
Z	Pressure nozzle	DN 80 *	DN 100 *

Flange connection required, see tables Page 94, Page 94

ELECTRICAL CONNECTIONS				
Connection	**Purpose**		**Inlet**	**Outlet**
U1	Position sensor: position display control slide / Vi-slide		24 V (DC)	4 - 20 mA
U2	Position sensor: position display control slide stop		24 V (DC)	4 - 20 mA
Y1	Solenoid valve	The function of each solenoid valve is described in the chapter "Solenoid valves" of Installation- and Maintenance manual.	220 V/ 230 V AC 110 V AC 24 V DC 230 V / 240 V AC, ATEX 110 V/ 120 V AC, ATEX	
Y2	Solenoid valve			
Y3	Solenoid valve			
Y4	Solenoid valve			

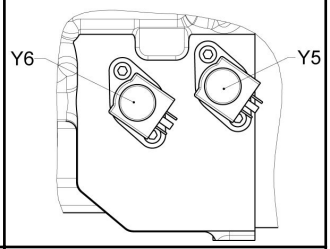
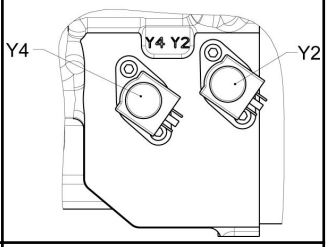
ELECTRICAL CONNECTIONS				
Connection	**Purpose**		**Inlet**	**Outlet**
Y5	Solenoid valve		24 V DC, ATEX	
Y6	Solenoid valve			
Y7	Solenoid valve (NO)	Hot gas pressurized check valve		

Flange connections



Flange connections, compressor frame sizes H, L				
	Suction nozzle A	**Pressure nozzle Z**	**Economizer R**	**Overflow valve connection X**
Di	Ø 125	Ø 80	Ø 44	Ø 76
D	Ø 190	Ø 135	Ø 85	Ø 135
Da	Ø 230	Ø 170	Square 85	Square 132
M	M16	M16	M12	M16
T1	27	28	27	25
n	8	4	4	4
Form	B	B	A	B
O-Ring	150 x 5	100 x 5	55 x 3	90 x 5

Flange connections, compressor frame sizes M, N				
	Suction nozzle A	**Pressure nozzle Z**	**Economizer R**	**Overflow valve connection X**
Di	Ø 150	Ø 100	Ø 44	Ø 80
D	Ø 224	Ø 190	Ø 85	Ø 135
Da	Ø 260	Ø 235	Square 85	Square 132
M	M20	M20	M12	M16
T1	42	30	27	25
n	8	8	4	4
Form	B	B	A	B
O-Ring	180 x 5	130 x 5	55 x 3	90 x 5

<table>
<tr><th colspan="4">Description, arrangement of solenoid valves</th></tr>
<tr><th>Design</th><th>Compressor design</th><th>Vi</th><th>Detail * from connection diagram</th></tr>
<tr><td>"S"</td><td>"T"</td><td>Vi variable</td><td> 
</td></tr>
<tr><td rowspan="4">"M"</td><td rowspan="3">"S"
Standard
"T"
Triax</td><td>Vi fixed</td><td> 
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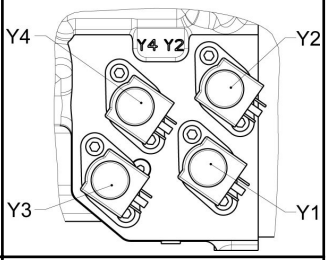
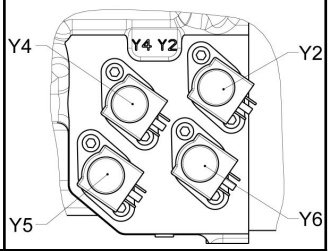
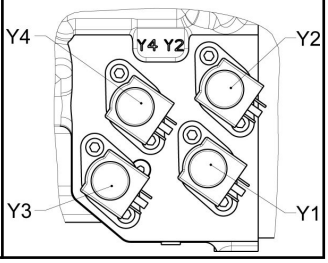
<tr><td>Vi fixed
Application
"SWING"</td><td> 
</td></tr>
<tr><td>Vi variable
Application
"SWING"</td><td>In this design, the solenoid valves are replaced by connection flanges. The power control and Vi-adjustment are carried out by solenoid valves or directional control valves arranged externally on the compressor unit.</td></tr>
<tr><td>Vi variable</td><td> 
</td></tr>
<tr><td>"B"
Booster</td><td>Vi fixed</td><td> 
</td></tr>
</table>

7.5 Conditions for Refrigerant Connections

Connection	Filter mesh size [µm]	Remarks
Suction nozzle upstream of the compressor	100 µm	
Pressure nozzle		During pressure compensation after stopping of the compressor, care should be taken to prevent foreign matter which are bigger than the mesh size in the suction filter from getting into the compressor together with refrigerant vapour flowing back from the plant components arranged downstream of the compressor.
	100 µm	A filter can be used as an option.
Economizer connection upstream of the compressor	100 µm	Area of application between 100% and approx. 70% control slide position, depending on the refrigerant requirements. At economiser operation during part-load operation, care should be taken to maintain the projected intermediate pressure.
Refrigerant injection connection upstream of the compressor	100 µm	Refrigerant injection should only be used in conjunction with inertia-free temperature measurement on the compressor pressure side (time constant k < 10 sec). When operating with refrigerant injection, the regulating valve should be sized to ensure that no liquid refrigerant enters the oil separator downstream.

⚠ Caution!

Destruction of the filters and the compressor by suctioned liquids

Liquid (refrigerant or oil) can lead to destruction of the filter at the suction nozzle and economizer connection.

► Ensure that no liquids are suctioned.

Notice

Practical advice Design of the connection pipelines!

► Due to the screw compressors working principles, dynamic pressure points occur proportionally to the drive speed multiplied by the number of teeth on the male rotor on the connection with the screw compressor. These loads need to be included when designing the connection pipes.

Notice

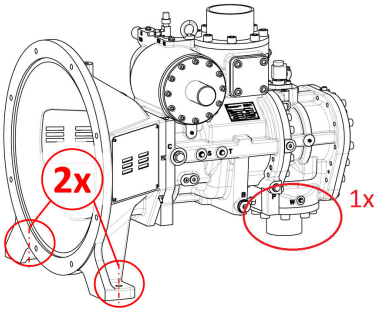
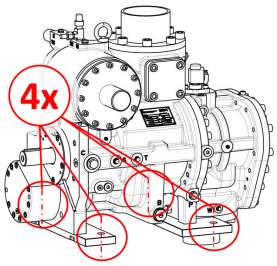
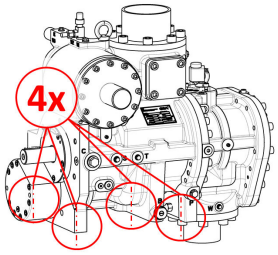
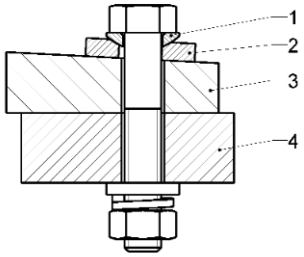
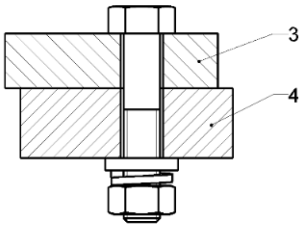
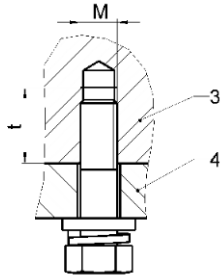
Instruction for routing the pipe at the discharge connection

► The piping must be laid in such a way that liquids can drain freely from the compressor into the oil separator.

7.6 Installation of the compressor

Installation conditions:	
compressor mounting surface	- overall evenness of mounting feet: 0.5 mm - support thickness: ≥ 25 mm

Mounting the compressor

Single settings with coupling housing	Single settings with mounting plate	Single setting
	Compressors in **single setting with mounting plates** can be swapped for previous compressors of the MC series of the same frame size. The mounting options for the compressor support surface of the compressor package and for the suction and pressure nozzle are the same.	Compressors in single setting can be fitted with mounting plates, in order to swap them for compressors of the same type from the MC series. There are special mounting conditions applied, which are supplied with the documentation for the mounting plates.
 2x mounting to the coupling housing, 1x mounting to the pressure nozzle	 4x mounting to the mounting brackets	 4x mounting to the compressor housing
 Fig.22	 Fig.23	 Fig.24

1	Spherical washer
2	Conical seal
3	Coupling housing
4	Screw Compressor Package

3	Mounting plate, screwed with the compressor
4	Screw Compressor Package

3	Compressor
4	Screw Compressor Package
M	Frame sizes H, L: M16; Frame sizes M, N: M20
t	Frame sizes H, L: 32 mm; Frame sizes M, N; 40 mm

Mounting the compressor		
Single settings with coupling housing	**Single settings with mounting plate**	**Single setting**
Notice Information on the safe stability and safe function of the compressor. ► The height and angle offset between the pressure nozzle and the supporting surface of the coupling housing must be compensated.	**Notice** Information on the safe stability and safe function of the compressor. ► The height and angle offset between the pressure nozzle and the supporting surface of mounting plate must be compensated.	**Notice** Information on the safe stability and safe function of the compressor. ► The height and angle offset between the pressure nozzle and the supporting surface of the compressor housing must be compensated.
During the annual maintenance of the compressor, the mounting screws of the compressor must be retightened to the tightening torques given in the table Page 98.		

Required tightening torque of the mounting screws of the compressor		
Compressor- Frame size	**Screw/thread**	**Tightening torque [1] Nm**
H, L, M, N with coupling housing	M20	425
H, single setting	M16	210
L, single setting		
M, single setting	M20	425
N, single setting		
[1] based on screw quality 8.8 and friction coefficient 0.14		

Drive motor, coupling

For single setting without coupling housing, the alignment of the drive motor to the compressor must be done according to the requirements of the coupling manufacturer. Familiarise yourself with the installation instructions of the coupling manufacturer and use them according to these instructions. The alignment of the drive motor must be repeated after the initial assembly at operating temperature. Retain a logged record of the alignment.

7.7 Technical requirements for couplings

When using a coupling not supplied from the manufacturer the following conditions need to be met:

Parameter		Compressor frame size	
		H, L	M, N*
			28 bar
			52 bar
Max. Driving power (60 Hz)	kW	360	360
			640
Nominal torque	Nm	960	960
			1700
Max. Start-up torque	Nm	2400	2400
			4200
Max. Speed	rpm	4500	
Maximum dynamic unbalance allowable	gcm	30	
permissible radial force F_R 1)	N	700	
permissible axial force F_A	N	300	
shaft diameter Compressor	mm	50 h6	50 h6
			60 h6
min. distance between Shaft ends compressor/motor2)	mm	70 +5	

*) For frame sizes M/N, the compressor drive shaft ends are different for 28 bar and 52 bar versions.

1) Permissible forces that may impact the compressor shaft end. The selection of coupling and the orientation are to be set up so that this force is not exceeded.

2) Values apply to simply functioning mechanical shaft seals (Standard). When using double mechanical seals contact needs to be made with manufacturer.

The maximum permitted drive capacities listed are upper limits determined by the drive shaft ends. Due to wear on the bearings, these drive forces shall not be achieved within a compressor size for all the available flow volumes. The review will be carried out in the compressor selection program.

Further conditions:	
design of the compressor shaft end:	cylindrical with feather key.
attachment of the compressor shaft end:	by means of a firmly tightened clamping joint with additional key.
Direction of rotation:	clockwise and counter clockwise
Start up and shut down frequency	maximum 10 per hour
operating temperature range:	- 20 °C to + 55 °C for dynamic operating load

7.8 Vibrations, sound, permissible piping loads; frame sizes H, L, M, N

Vibrations			
Main excitation frequencies	**Speed**		
	3000 rpm	**3600 rpm**	**4500 rpm**
f^1	50	60	75
f^2	100	120	150
f^3	250	300	375
f^4	500	600	750

Balance grade	
Balance grade of rotors	**Compressor frame size**
	H, L, M, N
Balance grade G (mm/s) acc. DIN ISO 21940	G 4,0

Vibration limit values	
Compressor frame size	**Effective vibration velocity/ RMS [1)]** **in frequency range A between 10 and 1000 Hz [2)]**
	Permissible limit value (mm/s) [3)4)5)6)]
H, L, M, N	5.0

1) Measuring method according to DIN ISO 10816.

2) Frequency range to be measured, minimum up to 1000 Hz; above 4000 rpm, minimum up to 1500 Hz

3) In case of rigid installation of compressor.

4) The installation of compressor as well as the design of frame and pipes of the package must be considered so that the limit values of vibration velocity do not exceed.

5) Limit values are valid up to 3000 rpm. For a speed of 3600 rpm and higher the limit value must be multiplied by 1.2.

6) The expected value of effective vibration velocity during trouble-free continuous operation is 50% of the above mentioned limit value with optimal frame design.

Recommended monitoring limits:

WARNING: 75... 100% of the permissible limit value

SHUTDOWN: 115...140% of the permissible limit value

Notice

Practical note: Limit values standstill monitoring, standstill measurement

If the effective vibration velocity measured at standstill is more than 25% of the specified limit value:

► Reduce the influence of the spurious oscillations.
► Avoid sudden excitations.

Mass moment of inertia, torsional stiffness of the compressor rotor pair

Notice

Prescription Torsional analysis of drive train

► Careful mechanical design and construction of the compressor unit.
► Performance of a torsional analysis of the drive train to ensure safe operation outside the critical torsional natural frequencies.

The values of the mass moment of inertia and torsional stiffness of the compressor rotor pair required for the torsion analysis are given in the table below. The values are valid for compressors with a maximum discharge pressure of 28 bar in compressor designs "B", "S", "R". Values for different compressor designs can be obtained from the manufacturer.

Values for torsional analysis				
	Compressor frame size			
	H	L	M	N
Mass moment of inertia [kg m^2]	0.109	0.128	0.224	0.272
Torsional stiffness [kNm/rad]	240	240	234	234

Sound

Emitted sound values					
Compressor frame size		**H**	**L**	**M**	**N**
Sound power level L_{WA}	dB (A)	86	87	88	88
Emission sound pressure level L_{pA}	dB (A)	72	73	74	74

The sound power of the compressor depends on its capacity and varies with the operating conditions of the plant. The emitted sound is caused by the compression process, gas pulsations and vibrations. The noise level is strongly influenced by the interaction between the compressor and the compressor package. In practice, the sound power levels may differ from the specified values.

The indicated values apply only for the following operating conditions with a variation of ± 3 dB:

- Speed n=2900 ... 3100 rpm
- Oil temperature 45...55 °C
- Medium NH3 (R717)
- Operating points t_0/t_c [°C]: 5/50; -10/45; -35/40; without economizer
- Operating points p_0/p_c [bar.a]: 5,2/20,3; 2,9/17,8; 0,96/15,5; without economizer

The inner volume ratio must be the best Vi value calculated in the compressor selection program for the specified operating point.

The emission sound pressure level L_{pA} in dB(A) at a distance of 1 m from the machine surface (A near level with free field conditions on a reflective base area) is a table value reduced by 13 to 17 dB(A) compared to the sound power level L_{WA}.

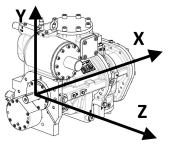
L_{WA}: A-weighted sound power level according to DIN EN ISO 9614-2 and DIN 45635, reference: 1 pW

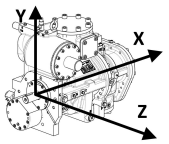
L_{pA}: A-weighted emission sound pressure level at 1 m distance according to DIN EN ISO 11203, reference: 20 µPa

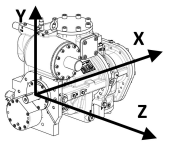
Notice

Practical advice Design of the connection pipelines!

► Due to the working principle of the screw compressor, dynamic pressure points occur at the connections of the screw compressor, particularly at the pressure nozzle, at a frequency that is proportional to the drive speed multiplied by the number of teeth of the male rotor.
► The design of the connecting pipelines must consider the critical pipe lengths depending on the speed of sound, in order to avoid resonances.
► The sound emission of the package is significantly influenced by such pressure pulsations in piping systems.

PERMISSIBLE PIPING FORCES AND TORQUES: including gas forces					
Maximum permitted pressure	**Point of application**		**Vector** 	**Compressor frame size**	
				H/L	**M/N**
28 bar	Suction nozzle: Screw Strength class A2-70	Force [N]	|x|	2500	4800
			$\|y_{max}\|$	2500	4800
			$\|y_{min}\|$	-2500	-4800
			|z|	2500	4800
		Torque [Nm]	|x|	1100	2100
			|y|	1100	2100
			|z|	1100	2100
	Discharge nozzle: Screw Strength class 8.8	Force [N]	|x|	2800	3400
			|y|	2800	5300
			|z|	2800	3400
		Torque [Nm]	|x|	1200	2100
			|y|	1200	2100
			|z|	1200	2100
	Eco nozzle: Screw Strength class A2-70	Force [N]	|x|		
			|y|		
			|z|		
		Torque [Nm]	|x|		
			|y|		
			|z|		

PERMISSIBLE PIPING FORCES AND TORQUES: including gas forces					
Maximum permitted pressure	**Point of application**		**Vector** 	**Compressor frame size**	
				H/L	**M/N**
52 bar	Suction nozzle: Screw Strength class A2-70	Force [N]	|x|	1700	3500
			$\|y_{max}\|$	1700	3500
			$\|y_{min}\|$	-1700	-3500
			|z|	1700	3500
		Torque [Nm]	|x|	700	1600
			|y|	700	1600
			|z|	700	1600
	Pressure nozzle Screw Strength class 8.8	Force [N]	|x|	2600	3400
			|y|	2600	5300
			|z|	2600	3400
		Torque [Nm]	|x|	1100	2100
			|y|	1100	2100
			|z|	1100	2100
	Eco nozzle Screw Strength class A2-70	Force [N]	|x|		
			|y|		
			|z|		
		Torque [Nm]	|x|		
			|y|		
			|z|		

PERMISSIBLE PIPING FORCES AND TORQUES: including gas forces					
Maximum permitted pressure	**Point of application**		**Vector** 	**Compressor frame size**	
				H/L	**M/N**
63 bar	Suction nozzle: Screw Strength class A2-70	Force [N]	|x|	1200	2900
			$\|y_{max}\|$	1200	2900
			$\|y_{min}\|$	-1200	-2900
			|z|	1200	2900
		Torque [Nm]	|x|	500	1300
			|y|	500	1300
			|z|	500	1300
	Discharge nozzle: Screw Strength class 8.8	Force [N]	|x|	2500	3400
			|y|	2500	5300
			|z|	2500	3400
		Torque [Nm]	|x|	1100	2100
			|y|	1100	2100
			|z|	1100	2100
	Eco nozzle: Screw Strength class A2-70	Force [N]	|x|		
			|y|		
			|z|		
		Torque [Nm]	|x|		
			|y|		
			|z|		

Notice

Practical advice Design of the connection pipelines!

► Due to the screw compressors working principles, dynamic pressure points occur proportionally to the drive speed multiplied by the number of teeth on the male rotor on the connection with the screw compressor.

► These loads need to be included when designing the connection pipes.

7.9 Operation limits

The compressor and the installed components are designed for specific operating conditions which must be maintained for safe working of the compressor.

⚠ Caution!

Damage to the compressor and compressor package

► The following specified minimum and maximum limit values must be adhered to.
► The design-related maximum pressure as per the nameplate must not be exceeded.
► Beyond that, project-specific restrictions or limit values, which must be agreed separately, apply.

<table>
<tr><th colspan="7">Process parameters</th></tr>
<tr><td>Permissible pressure (EN 378)
(Gauge pressure)</td><td>p</td><td>max</td><td colspan="4">28 bar / 52 bar, according to the nameplate</td></tr>
<tr><td>Suction temperature [14]</td><td>t_{0h}</td><td>min</td><td colspan="4">- 60 °C</td></tr>
<tr><td>Discharge temperature</td><td>t_e</td><td>max</td><td colspan="4">120°C</td></tr>
<tr><td rowspan="2">Pressure ratio</td><td rowspan="2">p_c / p_0</td><td>min</td><td colspan="4">1.5 [15]</td></tr>
<tr><td>max</td><td colspan="4">22</td></tr>
<tr><td rowspan="2">Pressure difference</td><td rowspan="2">p_c - p_0</td><td rowspan="2"></td><td>Standard operation
with / without oil pump:[16]</td><td>Booster operation: [17]</td><td colspan="2">Application "SWING": [18]</td></tr>
<tr><td>min. 2.9 bar *</td><td>min. 0.8 bar
max. 2.9 bar</td><td colspan="2">min. 0.8 bar</td></tr>
<tr><td rowspan="2">Oil temperature</td><td rowspan="2">t_{oil}</td><td>min</td><td colspan="4">18°C</td></tr>
<tr><td>max</td><td colspan="4">80°C</td></tr>
<tr><td rowspan="6">Oil pressure [19]</td><td rowspan="6">p_{oil}</td><td rowspan="6"></td><td>Operation without oil pump:</td><td colspan="3">Operation with oil pump:</td></tr>
<tr><td rowspan="2">$p_{oil} \geq p_0 + 2$ bar [20]</td><td colspan="3">$p_{oil} \geq p_0 + 2$ bar [20]</td></tr>
<tr><td colspan="3">AND</td></tr>
<tr><td>AND</td><td colspan="3">$p_{oil} \leq p_c + 3.5$ bar [21]</td></tr>
<tr><td rowspan="2">$p_{oil} \geq p_c - 3$ bar [20]
$p_{oil} \leq p_c$ [22]</td><td colspan="3">AND</td></tr>
<tr><td colspan="3">$p_{oil} \geq p_c + 0,5$ bar</td></tr>
<tr><td rowspan="2">Oil viscosity [23]</td><td rowspan="2">v</td><td>min</td><td colspan="4">7 mm^2/s</td></tr>
<tr><td>max</td><td colspan="4">70 mm^2/s</td></tr>
</table>

14 A dry-saturated steam has to be ensured during the suction process (no liquid).
15 For compressors with reduced volume flows, this value could be exceeded.
16 compressors design "S", compressors design "M" with fixed and variable Vi.
17 with oil pump; compressors design "M", compressor design "B".
18 with oil pump; compressors design "M" with fixed Vi, equipped for "SWING" application.
19 The specified oil pressures are limit values. The compressor must be switched off when exceeding or falling below these values.
20 The periodic limitations, see start-up (Section 7.10.1, Page 110 ff.), must be observed.
21 Benchmark for setting on external oil pressure regulating valve $p_{oil} \leq p_c + 2.5$ bar
22 If $p_{oil} = p_c$ there is a danger of compressor damage as there is no oil flow.
23 When starting the compressor the maximum value can be temporarily exceeded.

Process parameters			
Suction filter mesh	W_s	max	100 µm
Mesh size Oil	W_{oil}	max	15 µm (function oil) in open processes (gas compression) • $\beta_{(15)} \geq 200$ 25 µm (function oil) in closed processes • $\beta_{(25)} \geq 200$

⚠ Caution!

Damage to the compressor due to lack of oil when operating without oil pump!

► Ensure the pressure difference p_c - p_0 = 2,9 bar.

► A check valve with referential suction pressure must be installed after the oil separator.

► For this a minimum pressure difference of 2.9 bar for the switch value must be adhered to.

Ambient conditions	
Ambient temperature	**Value range / to be observed**
Start-up Compressor	+5 °C ... +45 °C **Notice** Requirements on the minimum ambient temperature to avoid compressor damage. ► The minimum ambient temperature of 5°C must be reached at least 12 hours before start-up of the compressor.
Compressor operation	-20 °C ... +45 °C

Notice

Application instructions
► All requirements in chapters “Operating limits”, “Installation” and following requirements must be fulfilled to guarantee a save operation of the compressor.

Minimum suction overheating in compressor inlet: "wet" operation has to be avoided.
For π ≥ 8 gas vibration protection is required.
For CO_2 usage the use of a completely electrified oil pump for injection and function oil needs to be checked in all types depending on the operating conditions.
Due to the solubility of refrigerant in the oil following applies:

- for Ammonia:
  - **$t_e \geq t_{oil} + 5$ K**;
  - **$t_e \geq t_{oil} + 10$ K**, when using a PAG oil (solubility of the refrigerant in the oil).
- For R22, R134a, R404A, R407C, R410A, R507, CO_2, natural gas, hydrocarbon compounds:
  - **$t_e \geq t_{oil} + 10$ K**, wherein solubility of the refrigerant in the oil.

→ **To determine the permitted difference between the discharge temperature (t_e) and oil intake temperature (t_{oil}), the set viscosity and the solubility diagram for the refrigerant-oil pair from the lubrication supplier need to be adhered to.**

Ensure that the oil viscosity is 7...70 cSt for the oil supply to bearings. Take into account the drop in viscosity due to refrigerant dissolved in the oil!
Limits for temperature differences will be considered in compressor selection programs.
The oil temperature at the compressor inlet must be at least 18°C, the oil must be preheated if necessary.
The rate of temperature change at compressor suction side should not exceed 0,1 K/s.
For individual cases outside the permitted speed coordination needs to made with the manufacturer.

p_c	Discharge pressure / condensing pressure	t_{0h}	Suction temperature (compressor inlet)
p_0	Suction pressure	t_e	Discharge temperature (compressor outlet)
Δp	Pressure difference (p_c - p_0)	t_c	Condensing temperature
π	Pressure ratio (p_c/p_0)	t_{oil}	oil inlet temperature into the compressor

Notes:

1. During tests of a certain application case, all the conditions specified in the table must be considered and adhered to.
2. Should the given limits not be adhered to in individual cases, the manufacturer needs to be consulted.
3. In addition to the operating limits stated in the tables, the applicable operating conditions of the compressor type in question must also be considered (e.g. start-up regime, oil pressure, oil quantity, etc.).

4. 4.1 Style M: Depending on the refrigeration requirements, economiser operation takes place at a control slide position between 100% and approx. 70%.

   4.2 Design S: Depending on the refrigeration requirements, economiser operation takes place in a defined speed-range.

5. When using **R134a** as a refrigerant and a**evaporating temperature > 60 °C** the manufacturer must be consulted.

7.10 Start-up, frame sizes H, L, M, N

7.10.1 Initial operation

Notice

General requirements for the initial start-up of the compressor

► Before initial operation, the compressor must be checked by a specialist.
► Check the turning direction of the drive motor when the coupling is removed.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Carry out a pressure test according to the Installation and Maintenance Manual.
► Carry out a vacuum test according to the Installation and Maintenance Manual.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that safe supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

1. **Position of the Vi-slide / capacity slide in starting position**

   Design "S":

   - Before starting the driving motor:
     - Single compressor:

       The solenoid valves Y5 and Y6 will actuated and open.
     - DUO-Pack / MULTI-Pack, without oil pump:

       The solenoid valve Y6 will actuated and opens.
   - Starting the driving motor.
     - With starting the drive motor solenoid valve Y6 is actuated and remain opened, solenoid valve Y5 is deactivated and remain closed.
   - The driving motor moves up to start speed.
   - 20 seconds after reaching the start speed, releasing automatic Vi-adjustment.
   - The solenoid valve Y7 will actuated and closes.

   Design "M":

- **Before starting** the driving motor:
  - Single compressor:

    Vi-fixed: Actuation of the solenoid valves Y2 and Y4,

    Vi-variable: Actuation of the solenoid valves Y2, Y4, Y5 and Y6,

    Vi-fixed: Execution "B": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

    Vi-fixed: application "SWING": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,
  - DUO-Pack / MULTI-Pack, without oil pump:

    Vi-fixed: Actuation of the solenoid valve Y4,

    Vi-variable: Actuation of the solenoid valves Y4 and Y5,
  - DUO-Pack / MULTI-Pack, with oil pump:

    Vi-fixed: Actuation of the solenoid valve Y2,

    Vi-variable: Actuation of the solenoid valves Y2 and Y5,

    Vi-fixed: Execution "B": Actuation of the solenoid valves Y2 and Y3,

    Vi-fixed: application "SWING": Actuation of the solenoid valves Y2 and Y3,

  The valves are actuated in such a way that pressure compensation takes place at the piston of the control slide and the built-in spring can move the control slide into the MIN position.
- At start-up the current signal from the position indicator of the control slide, as specified on the position indicator must be:
  - 4... 5 mA (0%...6%).
- If after 180 sec. the above-mentioned current signal is not reached, the starting condition is extended to a current signal of:
  - 15 mA (0%...70%).
- **With start**of the drive motor, remain activated:
  - Vi-fixed: Solenoid valve Y2,
  - Vi-variable: Solenoid valves Y2 and Y5,
  - Vi-fixed, design "B": Solenoid valves Y2 and Y3,

  All other solenoids will deactivated with start of the drive motor and get closed.
  - Starting the external oil pump, if installed.
  - The solenoid valve Y7 will actuated and closes.

2. **Oil pressure**
   - For oil pressure see data sheet Section 7.9, Page 106.
3. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18°C (refer Section 7.9, Page 106).

     In the start phase, the oil viscosity can also briefly exceed the maximum value.
4. **Limiting time periods**

- **Limiting time periods**
  - Operation without oil pump:

    Within the first 20 seconds after starting the drive motor, the oil pressure monitor must be ignored.

    At the end of the 20 seconds, a differential pressure of "p_{oil} - p_0" > 0.5 bar must be maintained for the next 120 seconds.

    After the 120 seconds, the differential pressure must be "p_{oil} - p_0 " > 2 bar.

  - Operation with oil pump:

    Within 15 seconds after the drive motor has started, oil pressure must be $p_{oil} > p_0 + 2$ bar **and**$p_{oil} \geq p + 0{,}5$ bar. (p = pressure at the discharge side of the compressor; p_0 = suction pressure)

STOP CONDITIONS FOR COMPRESSORS OF THE M SERIES

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

With stop of the compressor motor, deactivate solenoid valve Y7.

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

Setting the discharge temperature

For adopting the discharge temperature to the operating conditions agreed in the project, the amount of injection oil injected into the compressor can be changed.

The requirements for this are:

- the compressor operates in the operating conditions agreed in the project (suction pressure, discharge pressure).
- the compressor operates in the maximum speed agreed in the project.
- the capacity control of the compressor is set to 100%power.
- or / and the variable Vi is set in the Vi-adjustment.

change the amount of injection oil injected by opening or closing the control valve: or in the supply line to the connection

- on connection B (Page 89)

or

- or in the supply line to connection B (Page 90).

Due to the inertia of the overall system, the change of the injected amount of oil must be carried out in small steps and with a holding time.

7.10.2 Start-up after long standstill period

Notice

General information on the safe start-up.

► Before start-up after long standstill periods, the compressor must be checked by instructed operating personnel.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

1. **Position of the Vi-slide / capacity slide in starting position**

Design "S":

- Before starting the driving motor:
  - Single compressor:

    The solenoid valves Y5 and Y6 will actuated and open.
  - DUO-Pack / MULTI-Pack, without oil pump:

    The solenoid valve Y6 will actuated and opens.
- Starting the driving motor.
  - With starting the drive motor solenoid valve Y6 is actuated and remain opened, solenoid valve Y5 is deactivated and remain closed.
- The driving motor moves up to start speed.
- 20 seconds after reaching the start speed, releasing automatic Vi-adjustment.
- The solenoid valve Y7 will actuated and closes.

Design "M":

- **Before starting** the driving motor:
  - Single compressor:

    Vi-fixed: Actuation of the solenoid valves Y2 and Y4,

Vi-variable: Actuation of the solenoid valves Y2, Y4, Y5 and Y6,

Vi-fixed: Execution "B": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

Vi-fixed: application "SWING": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

- DUO-Pack / MULTI-Pack, without oil pump:

  Vi-fixed: Actuation of the solenoid valve Y4,

  Vi-variable: Actuation of the solenoid valves Y4 and Y5,

- DUO-Pack / MULTI-Pack, with oil pump:

  Vi-fixed: Actuation of the solenoid valve Y2,

  Vi-variable: Actuation of the solenoid valves Y2 and Y5,

  Vi-fixed: Execution "B": Actuation of the solenoid valves Y2 and Y3,

  Vi-fixed: application "SWING": Actuation of the solenoid valves Y2 and Y3,

  The valves are actuated in such a way that pressure compensation takes place at the piston of the control slide and the built-in spring can move the control slide into the MIN position.

– At start-up the current signal from the position indicator of the control slide, as specified on the position indicator must be:
  - 4... 5 mA (0%...6%).
– If after 180 sec. the above-mentioned current signal is not reached, the starting condition is extended to a current signal of:
  - 15 mA (0%...70%).
– **With start**of the drive motor, remain activated:
  - Vi-fixed: Solenoid valve Y2,
  - Vi-variable: Solenoid valves Y2 and Y5,
  - Vi-fixed, design "B": Solenoid valves Y2 and Y3,

  All other solenoids will deactivated with start of the drive motor and get closed.
  - Starting the external oil pump, if installed.
  - The solenoid valve Y7 will actuated and closes.

2. **Oil pressure**
   – For oil pressure see data sheet Section 7.9, Page 106.
3. **Oil temperature**
   – The oil temperature upstream of the compressor must be at least 18°C (refer Section 7.9, Page 106).

     In the start phase, the oil viscosity can also briefly exceed the maximum value.
4. **Limiting time periods**
   - **Limiting time periods**
     – Operation without oil pump:

Within the first 20 seconds after starting the drive motor, the oil pressure monitor must be ignored.

At the end of the 20 seconds, a differential pressure of "p_{oil} - p_0" > 0.5 bar must be maintained for the next 120 seconds.

After the 120 seconds, the differential pressure must be "p_{oil} - p_0 " > 2 bar.

- Operation with oil pump:

  Within 15 seconds after the drive motor has started, oil pressure must be $p_{oil} > p_0 + 2$ bar **and** $p_{oil} \geq p + 0{,}5$ bar. (p = pressure at the discharge side of the compressor; p_0 = suction pressure)

STOP CONDITIONS FOR COMPRESSORS OF THE M SERIES

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

With stop of the compressor motor, deactivate solenoid valve Y7.

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

7.10.3 Automatic mode (Start-Stop mode)

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

Notice

General information on the safe start-up.

► Before start-up after long standstill periods, the compressor must be checked by instructed operating personnel.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF THE M SERIES

1. **Position of the Vi-slide / capacity slide in starting position**

Design "S":

- Before starting the driving motor:
  - Single compressor:

    The solenoid valves Y5 and Y6 will actuated and open.
  - DUO-Pack / MULTI-Pack, without oil pump:

    The solenoid valve Y6 will actuated and opens.
- Starting the driving motor.
  - With starting the drive motor solenoid valve Y6 is actuated and remain opened, solenoid valve Y5 is deactivated and remain closed.
- The driving motor moves up to start speed.
- 20 seconds after reaching the start speed, releasing automatic Vi-adjustment.
- The solenoid valve Y7 will actuated and closes.

Design "M":

- **Before starting** the driving motor:
  - Single compressor:

Vi-fixed: Actuation of the solenoid valves Y2 and Y4,

Vi-variable: Actuation of the solenoid valves Y2, Y4, Y5 and Y6,

Vi-fixed: Execution "B": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

Vi-fixed: application "SWING": Actuation of the solenoid valves Y1, Y2, Y3 and Y4,

- DUO-Pack / MULTI-Pack, without oil pump:

  Vi-fixed: Actuation of the solenoid valve Y4,

  Vi-variable: Actuation of the solenoid valves Y4 and Y5,

- DUO-Pack / MULTI-Pack, with oil pump:

  Vi-fixed: Actuation of the solenoid valve Y2,

  Vi-variable: Actuation of the solenoid valves Y2 and Y5,

  Vi-fixed: Execution "B": Actuation of the solenoid valves Y2 and Y3,

  Vi-fixed: application "SWING": Actuation of the solenoid valves Y2 and Y3,

  The valves are actuated in such a way that pressure compensation takes place at the piston of the control slide and the built-in spring can move the control slide into the MIN position.

– At start-up the current signal from the position indicator of the control slide, as specified on the position indicator must be:
  - 4... 5 mA (0%...6%).
– If after 180 sec. the above-mentioned current signal is not reached, the starting condition is extended to a current signal of:
  - 15 mA (0%...70%).
– **With start**of the drive motor, remain activated:
  - Vi-fixed: Solenoid valve Y2,
  - Vi-variable: Solenoid valves Y2 and Y5,
  - Vi-fixed, design "B": Solenoid valves Y2 and Y3,

  All other solenoids will deactivated with start of the drive motor and get closed.
  - Starting the external oil pump, if installed.
  - The solenoid valve Y7 will actuated and closes.

2. **Oil pressure**
   – For oil pressure see data sheet Section 7.9, Page 106.
3. **Oil temperature**
   – The oil temperature upstream of the compressor must be at least 18°C (refer Section 7.9, Page 106).
   In the start phase, the oil viscosity can also briefly exceed the maximum value.
4. **Limiting time periods**
   - **Limiting time periods**

- Operation without oil pump:

  Within the first 20 seconds after starting the drive motor, the oil pressure monitor must be ignored.

  At the end of the 20 seconds, a differential pressure of "p_{oil} - p_0" > 0.5 bar must be maintained for the next 120 seconds.

  After the 120 seconds, the differential pressure must be "p_{oil} - p_0 " > 2 bar.

- Operation with oil pump:

  Within 15 seconds after the drive motor has started, oil pressure must be p_{oil} > p_0 + 2 bar **and**p_{oil} ≥ p + 0,5 bar. (p = pressure at the discharge side of the compressor; p_0 = suction pressure)

STOP CONDITIONS FOR COMPRESSORS OF THE M SERIES

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

With stop of the compressor motor, deactivate solenoid valve Y7.

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

8 LT series; frame sizes P - XH

8.1 Nominal data; frame sizes P, R, S, T, V, W, Y

		Compressor frame size						
		P	**R**	**S**	**T**	**V**	**W**	**Y**
Suction volume flow*) at 2940 min^{-1}	[m^3/h]	805	1040	1290	1460	1740	1990	2390
Number of teeth per rotor MR/FR	[-]	5/6						
Speed, max	[rpm]	3600	4500			3600		
Speed, min	[rpm]	1500						
Range of capacity control, stepless		10% **)... 100 %						
Types of Vi design (fixed Vi)		1.8; 2.0; 2.2; 2.6; 3.0; 3.6; 4.8; 5.5						
Vi adjustment ranges		1.8...3.0 2.2...4.0 2.6...5.5						
Weight *)	[kg]	598	890	960	1060	1280	1330	1390
Max. Drive power at 3000 min^{-1}	[kW]	530				1250		
Max. Drive power at 3600 min^{-1}		640				1500		
Max. Drive power at 4500 min^{-1}		-	800			-		
Max. Nominal torque ***)	[Nm]	1700				4000		

*) depending on the flow rate, the compressor design and the use of special and additional components, this value may deviate.

**) depending on operating conditions, this value may deviate.

***) When running the compressor with a non-electrical drive, the maximum torque is reduced by 25%.

8.2 Nominal data; frame sizes Z, XA; XB, XC, XD; XE, XF

		Compressor frame size						
		Z	**XA**	**XB**	**XC**	**XD**	**XE**	**XF**
Suction volume flow*) at 2940 rpm	[m³/h]	2748	3250	4150	4900	5800	7170	8560
Number of teeth per rotor MR/FR	[-]	5/6						
Speed, max	[rpm]	3600						
Speed, min	[rpm]	1500						
Range of capacity control, continuous		10% **)... 100%						
Types of Vi design (fixed Vi)		1.8; 2.0; 2.2; 2.6; 3.0; 3.6; 4.8; 5.5						
Vi adjustment ranges		1.8...3.0 2.2...4.0 2.6...5.5						
Weight *)	[kg]	1670	1740	2400	2560	2650	3500	3800
Max. drive power at 50 Hz	[kW]	1250		1800			3280	
Max. drive power at 60 Hz		1500		2160			3940	
Max. nominal torque ***)	[Nm]	4000		5750			10440	

*) This value may vary depending on the swept volume letter, the compressor design and the use of special and additional components.

**) This value may vary depending on the operating conditions.

***) When running the compressor with a non-electrical drive, the maximum torque is reduced by 25%.

8.3 Nominal data; frame sizes XG, XH

		Compressor frame size	
		XG	**XH**
Suction volume flow*) **at 2940 min^{-1}**	[m³/h]	9807	11467
	[cfm]	5772	6749
Suction volume flow*) **at 3550 min^{-1}**	[m³/h]	11841	13846
	[cfm]	6970	8150
Number of teeth per rotor MR/FR	[-]	5/6	
Speed, max	[rpm]	3600	
Speed, min	[rpm]	1500	
Range of capacity control, stepless		10% **)... 100 %	
Types of Vi design (fixed Vi)		1.8; 2.0; 2.2; 2.6; 3.0; 3.6; 4.8; 5.5	
Vi adjustment ranges		1.8...2.8 2.2...3.8 2.6...5.2	
Weight *)	[kg]	4900	5200
Max. Drive power at 2940 min^{-1}	[kW]	3472	3472
Max. Drive power at 3550 min^{-1}		4193	4193
Max. Nominal torque ***)	[Nm]	11278	11278

*) depending on the flow rate, the compressor design and the use of special and additional components, this value may deviate.

**) This value may vary depending on the operating conditions.

***) When running the compressor with a non-electrical drive, the maximum torque is reduced by 25%.

8.4 Main dimensions; frame sizes P, R, S, T, V, W, Y

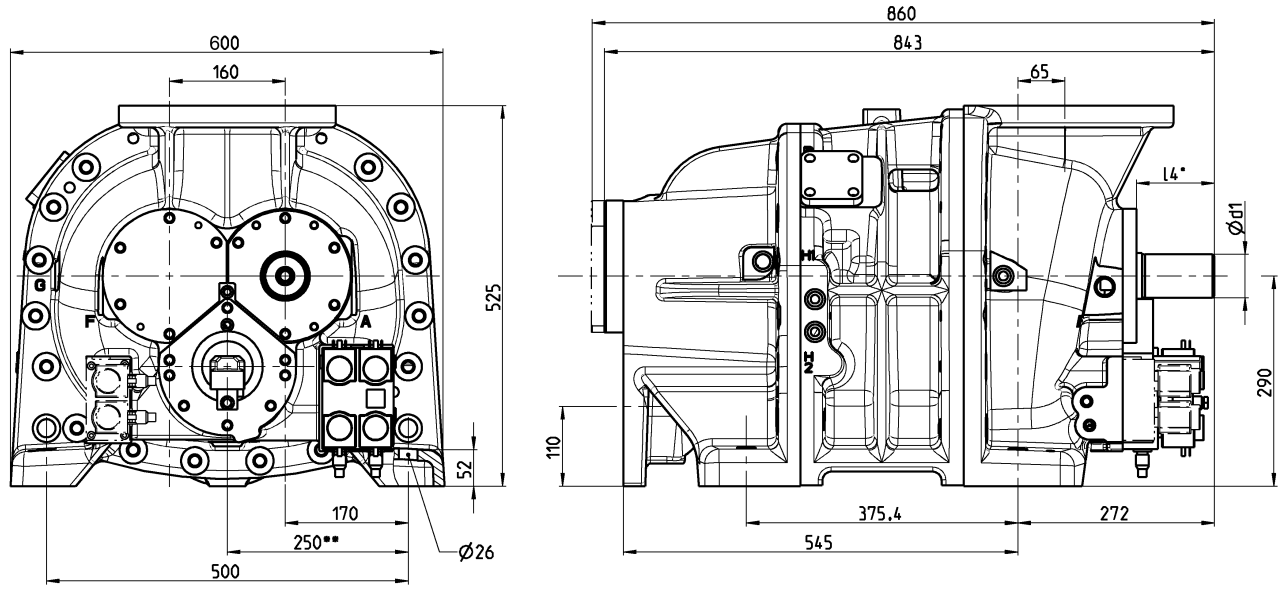
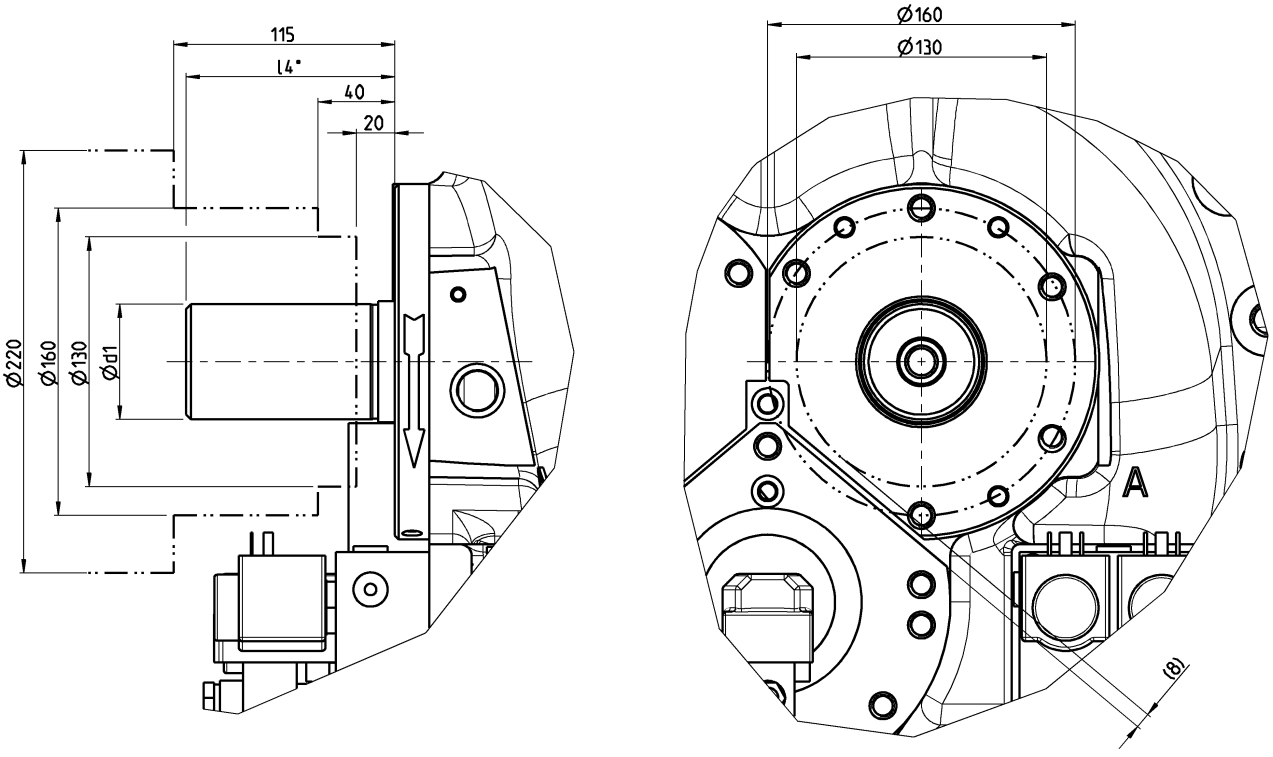


Fig.25: Frame size P

**	position discharge connection
	Dimension 860 for Compressor Design "T", Triax



Main dimensions		Frame size
		P
d1		Ø 60 h6
l4 * (Coupling seat)	Single shaft sealing	108
	Dual shaft sealing	104
approx. Weight (kg)		598

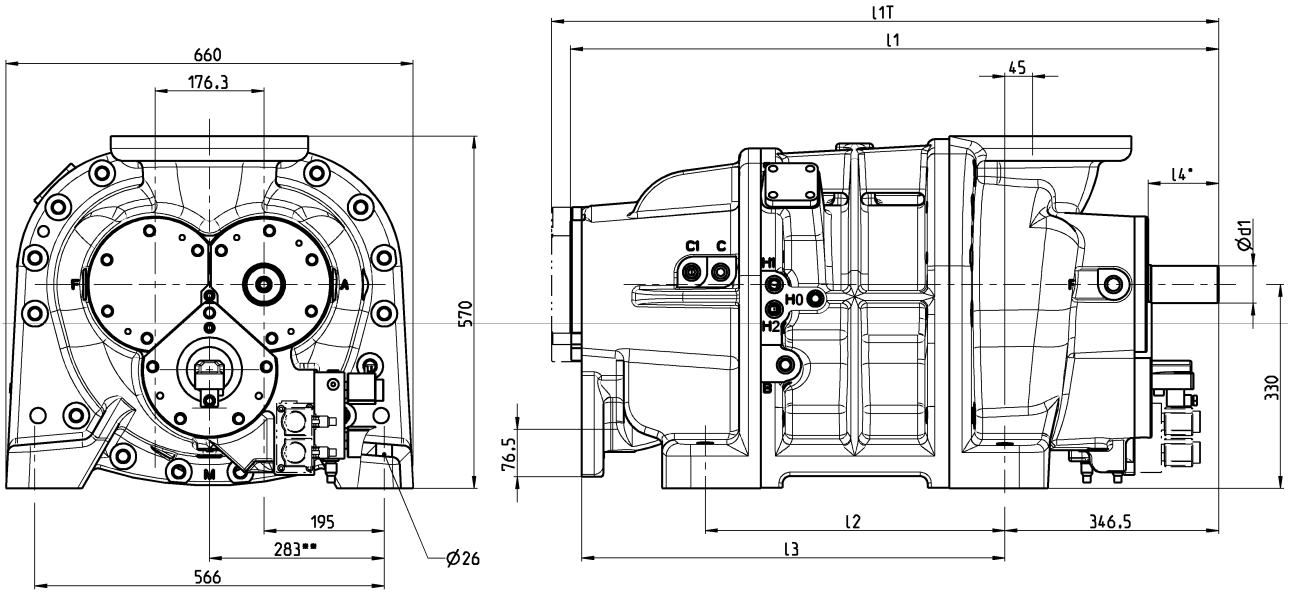


Fig.26: Frame sizes R, S, T

**	position discharge connection

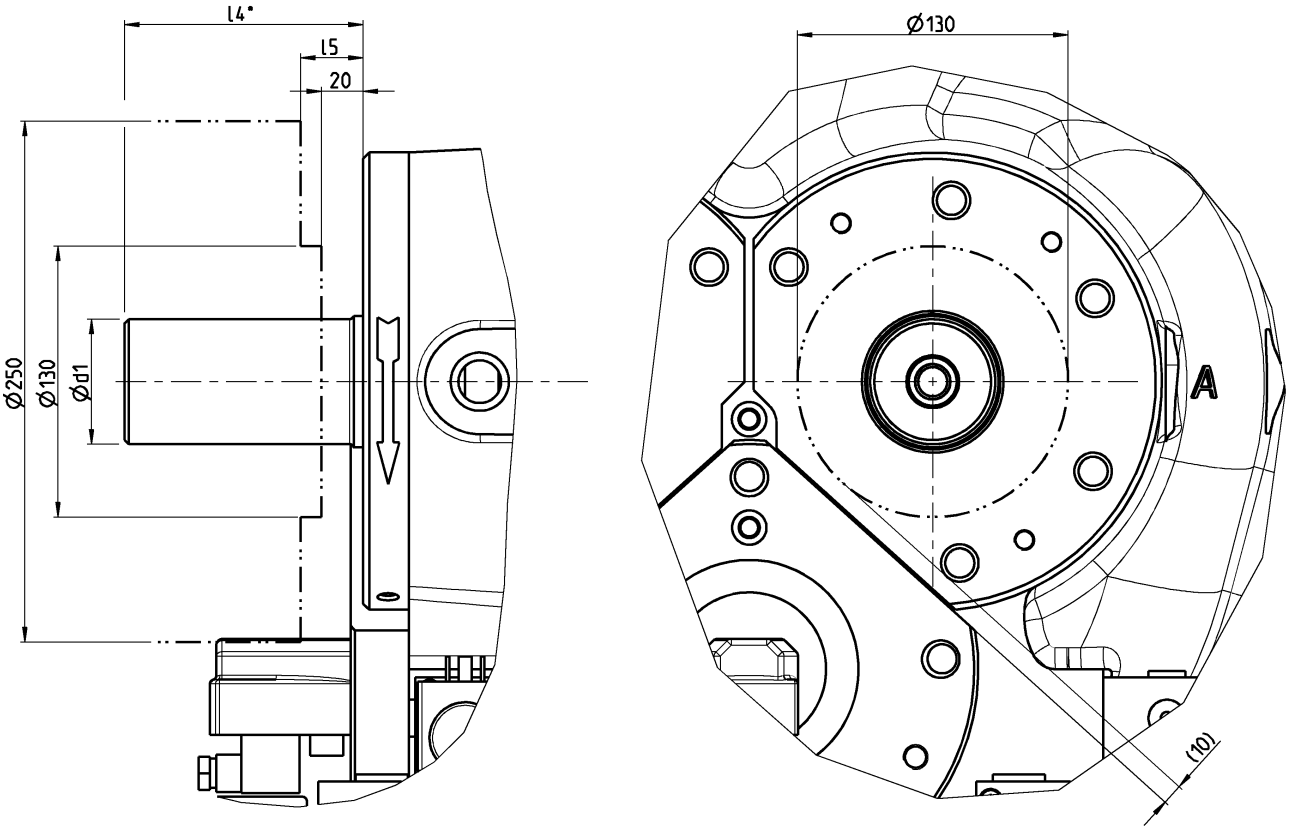


Fig.27

Main dimensions		Frame size		
		R	**S**	**T**
d1		Ø 60 h6		
l1		989.5	1050	1090
l1T		1014.5	1081	1121
l2		419	485.5	525.5
l3		619	685.5	725.5
l4 * (coupling seat)	Single shaft sealing	115		
	Dual shaft sealing	94		
l5		20	20	50
Connection	Suction side	DN 175		
	Discharge side	DN 100		
	Eco (economizer) MR	-		
	Eco (economizer) FR	DN 40		
	Refrigerant liquid injection	DN 15		
approx. Weight (kg)		890	960	1060

l1T: at max. permitted pressure of 52 bar or on triax bearings, see also Section 3.1, Page 12, Type Designation

* Observe the centrifugal area of the coupling'.

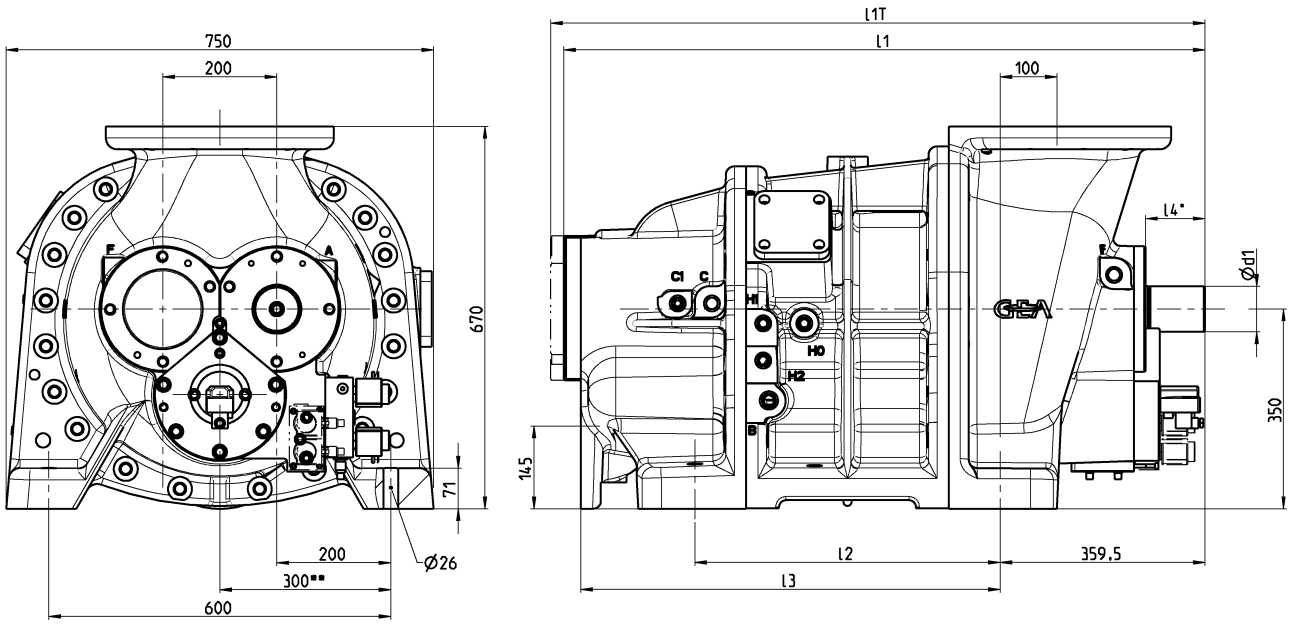


Fig.28: Frame sizes V, W, Y

**	position discharge connection

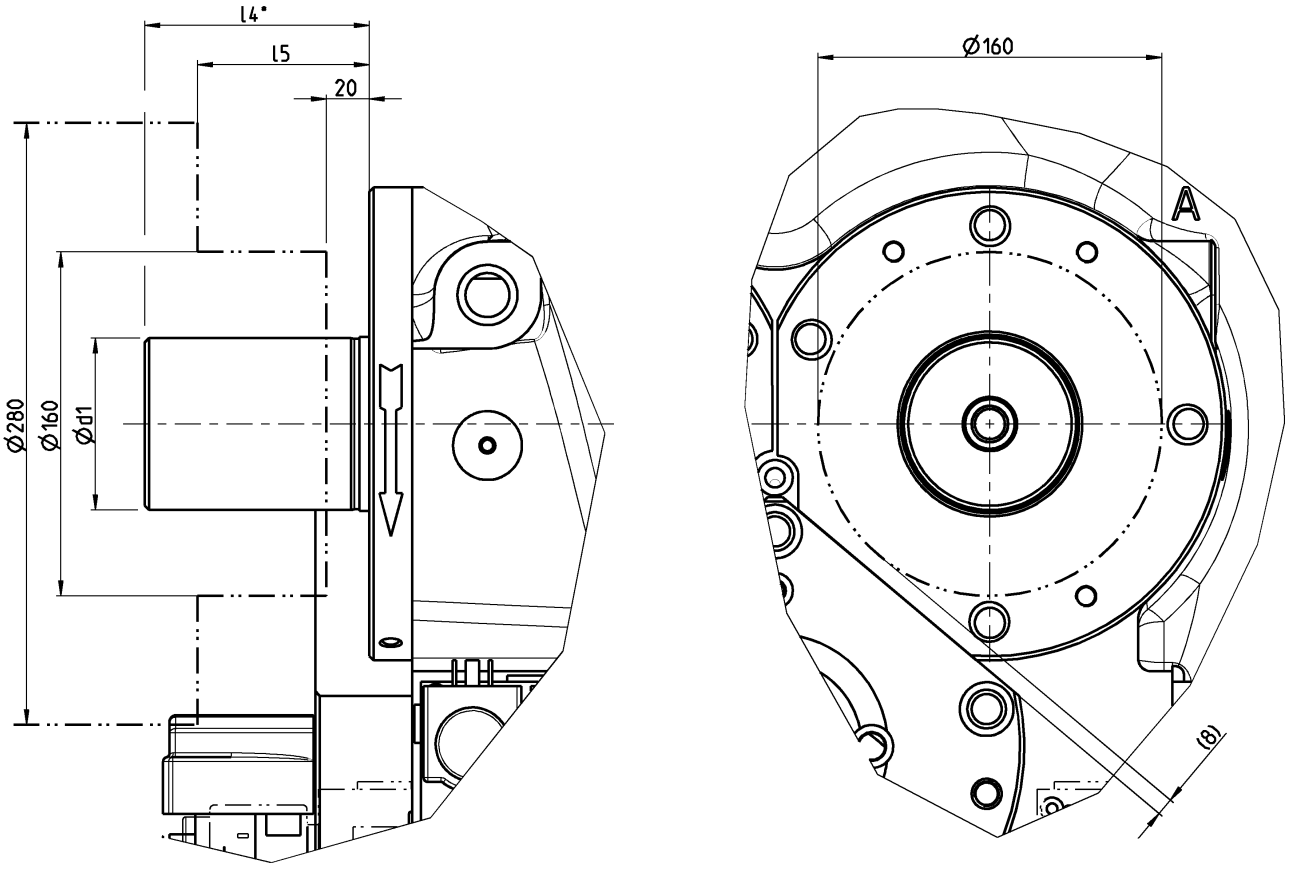


Fig.29

Main dimensions		Frame size		
		V	**W**	**Y**
d1		Ø 80 h6		
l1		1076	1130	1195
l1T		1103	1158	1223
l2		480.5	535.5	600.5
l3		680.5	735.5	800.5
l4 * (coupling seat)	Single shaft sealing	104.5		
	Dual shaft sealing	104.5		
l5		30		65
Connection	Suction side	DN 250		
	Discharge side	DN 150		
	Eco (economizer) MR	DN 65		
	Eco (economizer) FR	DN 65		
	Refrigerant liquid injection	DN 15		
approx. Weight (kg)		1280	1330	1390

l_1T: at max. permitted pressure of 52 bar or on triax bearings, see also Section 3.1, Page 12, Type Designation

* Observe the centrifugal area of the coupling'.

8.5 Main dimensions; frame size Z, XA, XB, XC, XD

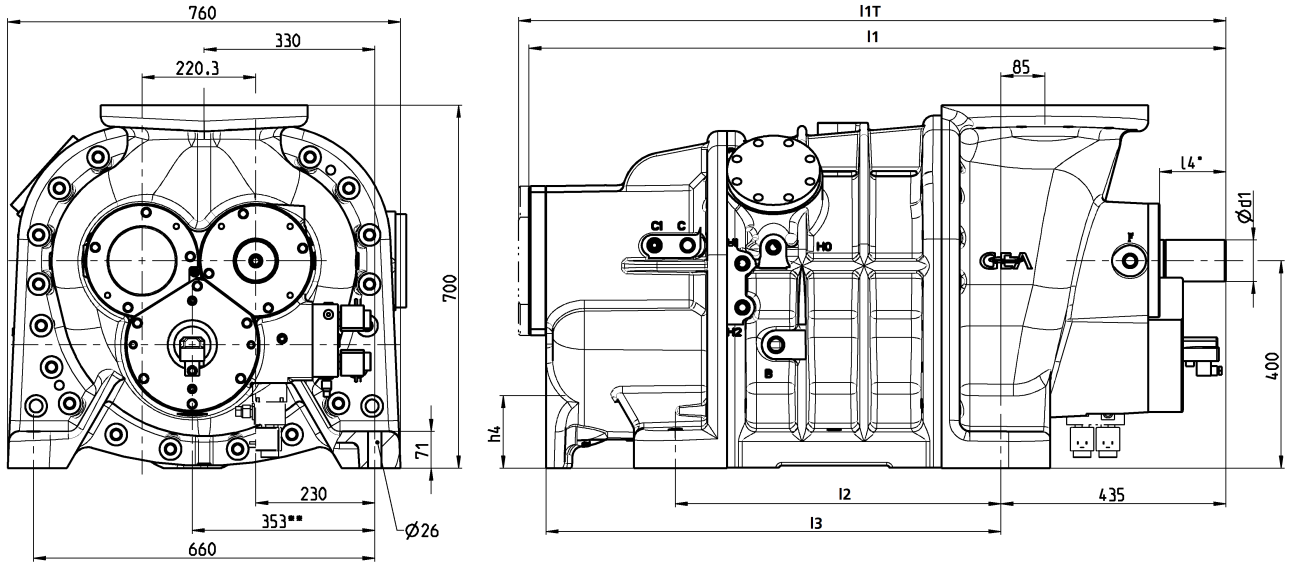
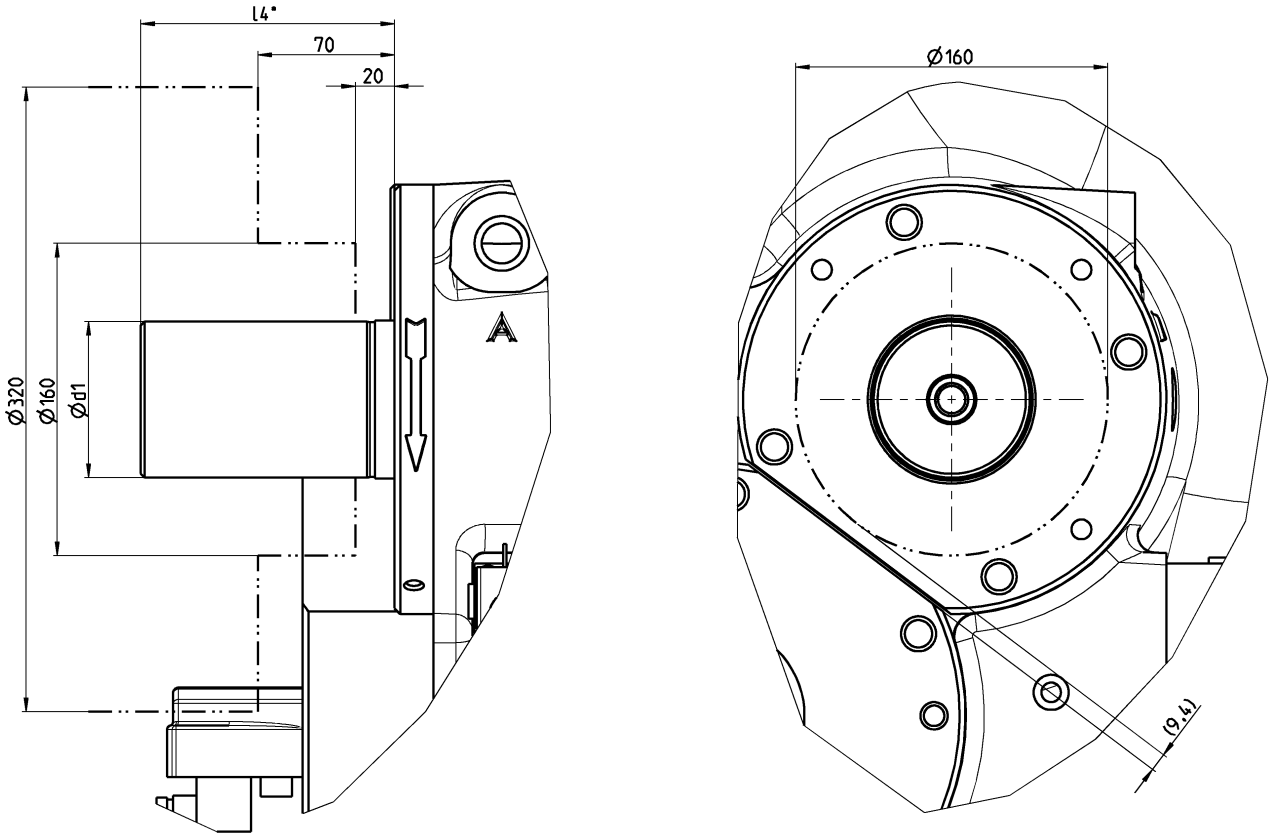


Fig.30: Frame sizes Z, XA

**	Position discharge connection



Main dimensions		Frame size	
		Z	**XA**
d1		Ø 80 h6	
h4		140	
l1		1348	1423
l1T		1368	1443
l2		630	705
l3		880	955
l4 (coupling seat)	Simple- GLRD	130	
	Double- GLRD	105	
Connection	Suction side	DN 250	
	Pressure side	DN 150	
	Charge (economizer) MR	DN 100	
	Charge (economizer) FR	DN 100	
	Refrigerant liquid injection	DN 15	
approx. weight, max. (kg)		1670	1740

l1T: at maximum permitted pressure of 52 bar or on triax bearings, see also Section 3.1, Page 12, product designation

* The centrifugal area of the coupling needs to be taken into account.

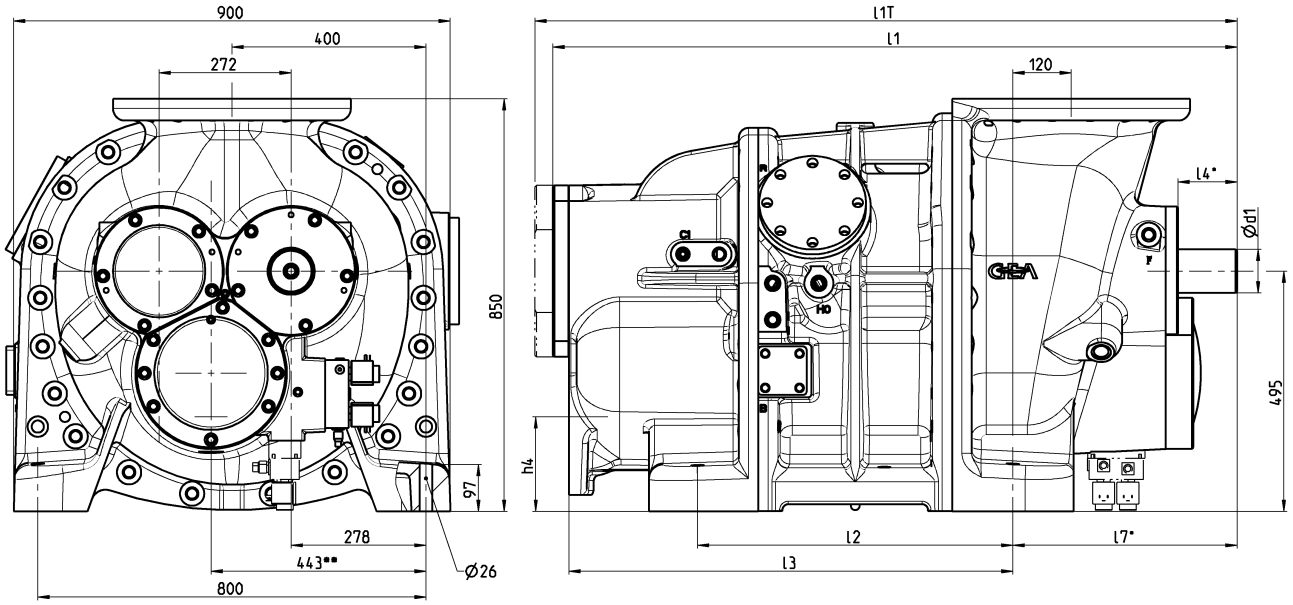
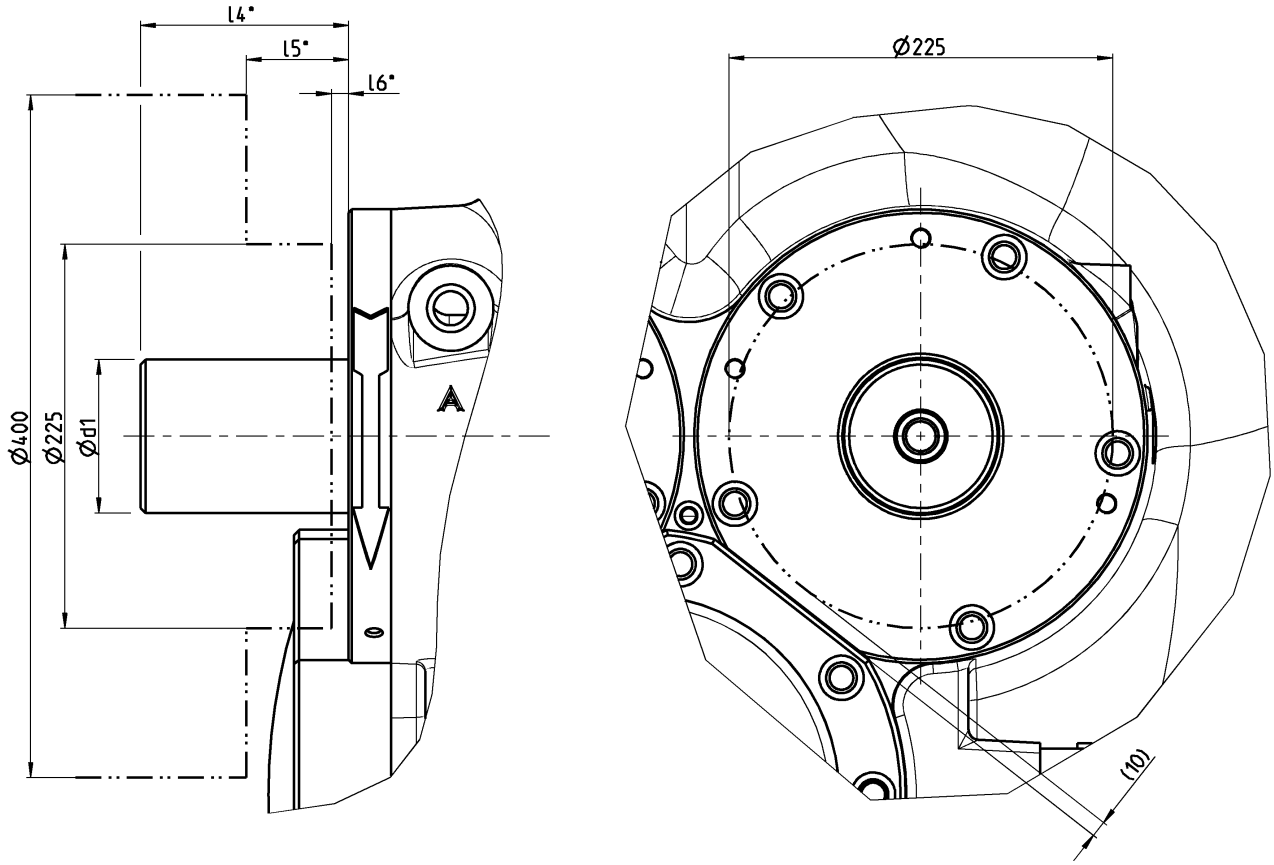


Fig.31: Types XB, XC, XD

**	Position discharge connection



Main dimensions		Frame size		
		XB	**XC**	**XD**
d1		Ø 90 h6		
h4		195		
l1		1410 / 1440**	1477 / 1507**	1560 / 1590**
l1T		1447 / 1477**	1514 / 1544**	1597 / 1627**
l2		650	717	800
l3		915	982	1065
l4 (coupling seat)		122		
l5		35 / 30 **		80 / 75 **
l6		17 / 25 **		
l7		462 / 492 **		
Connection	Suction side	DN 300		
	Pressure side	DN 200		
	Charge (economizer) MR	DN 125		
	Charge (economizer) FR	DN 125		
	Refrigerant liquid injection	DN 18		
approx. weight, max. (kg)		2400	2560	2650

l1T: at maximum permitted pressure of 52 bar or on triax bearings, see also Section 3.1, Page 12, product designation

*The centrifugal area of the coupling needs to be taken into account.

** for execution with double mechanical shaft-seal.

8.6 Main dimensions; frame sizes XE, XF

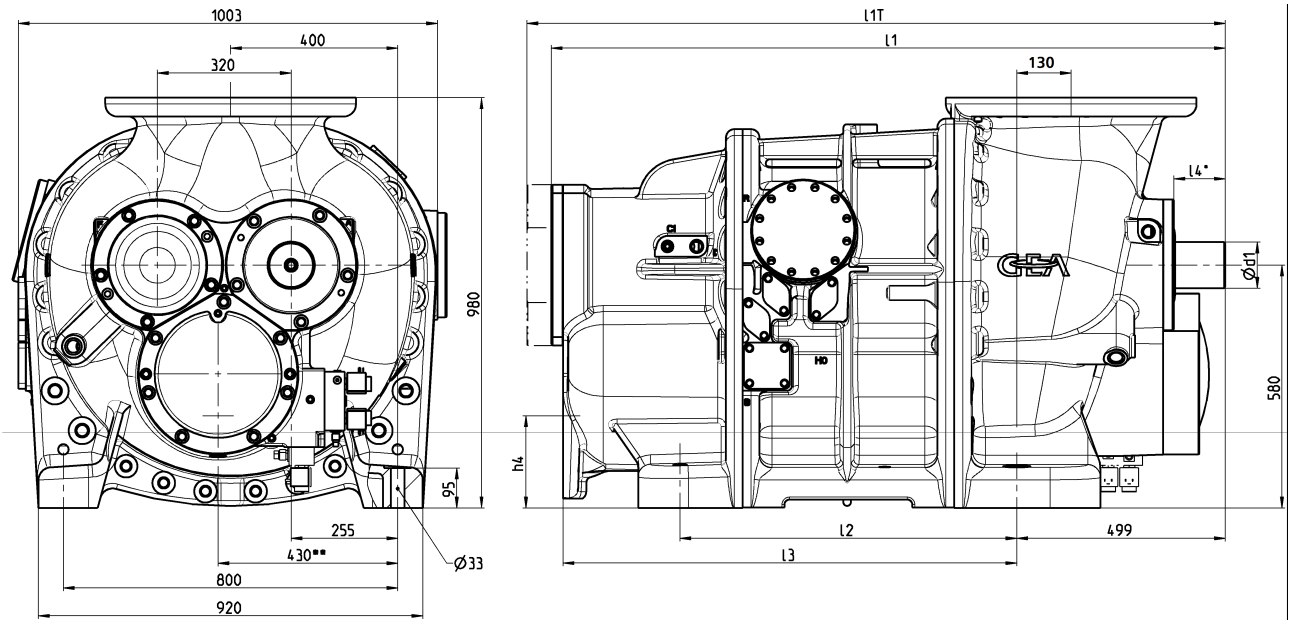
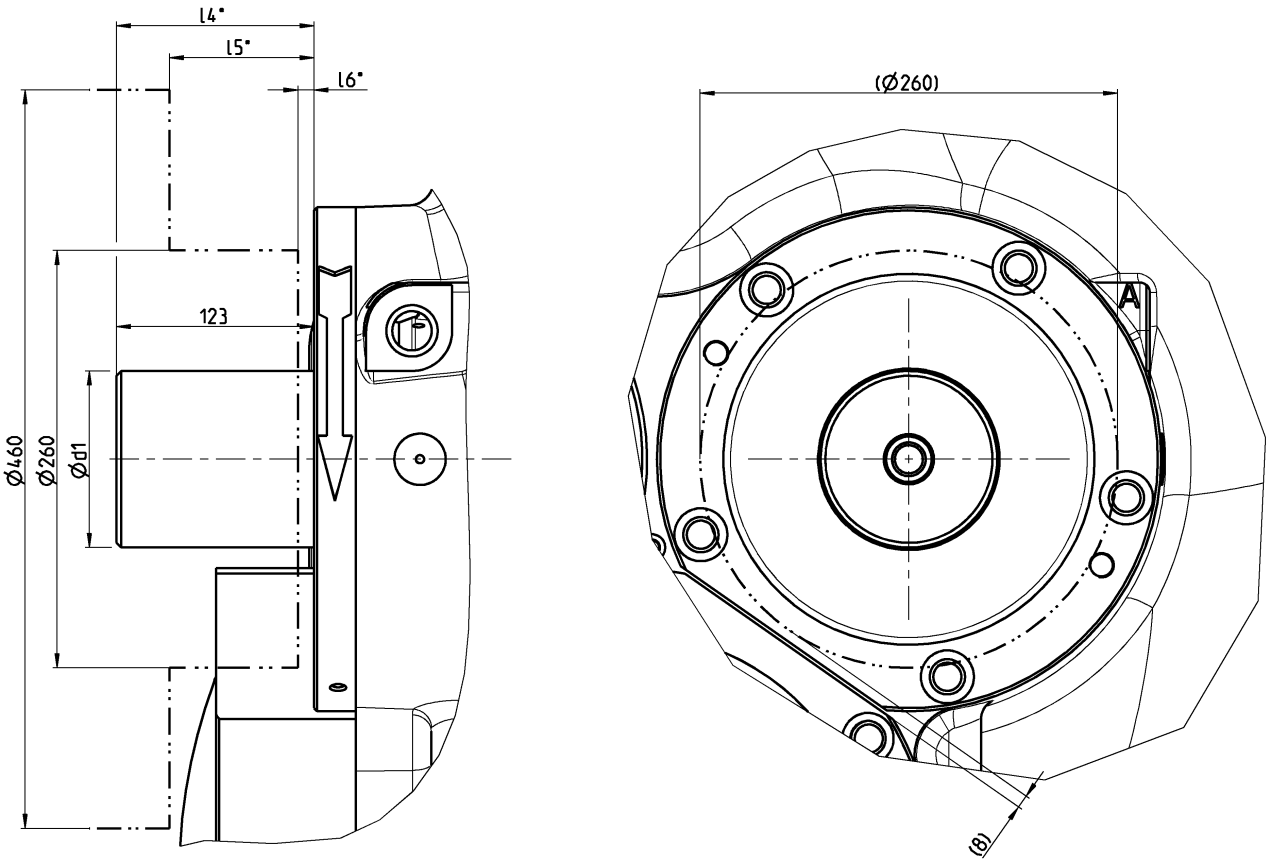


Fig.32: Frame sizes XE, XF

**	Position discharge connection



Main dimensions		Frame size	
		XE	**XF**
d1		Ø110 h6	
h4		220	
l1		1614	1713
l1T		1672	1771
l2		806	905
l3		1086	1185
l4*		124 (80 / 108 / 110) **	
l5		25	75
l6		10 / 16 **	
Connection	suction side	DN 400	
	pressure side	DN 250	
	Charge (Economizer) MR	DN 150	
	Charge (Economizer) FR	DN 150	
	Oil injection	DN 50	
	Refrigerant liquid injection	DN 25	
approx. weight, max. (kg)		3500	3800

l_1T: at max. permissible pressure of 52 bar or on triax bearings, refer also to the Product designation chapter.

* The centrifugal area of the coupling needs to be taken into account.

** with the version with double-acting shaft seal, depending on the application and manufacturer.

8.7 Main dimensions; frame sizes XG, XH

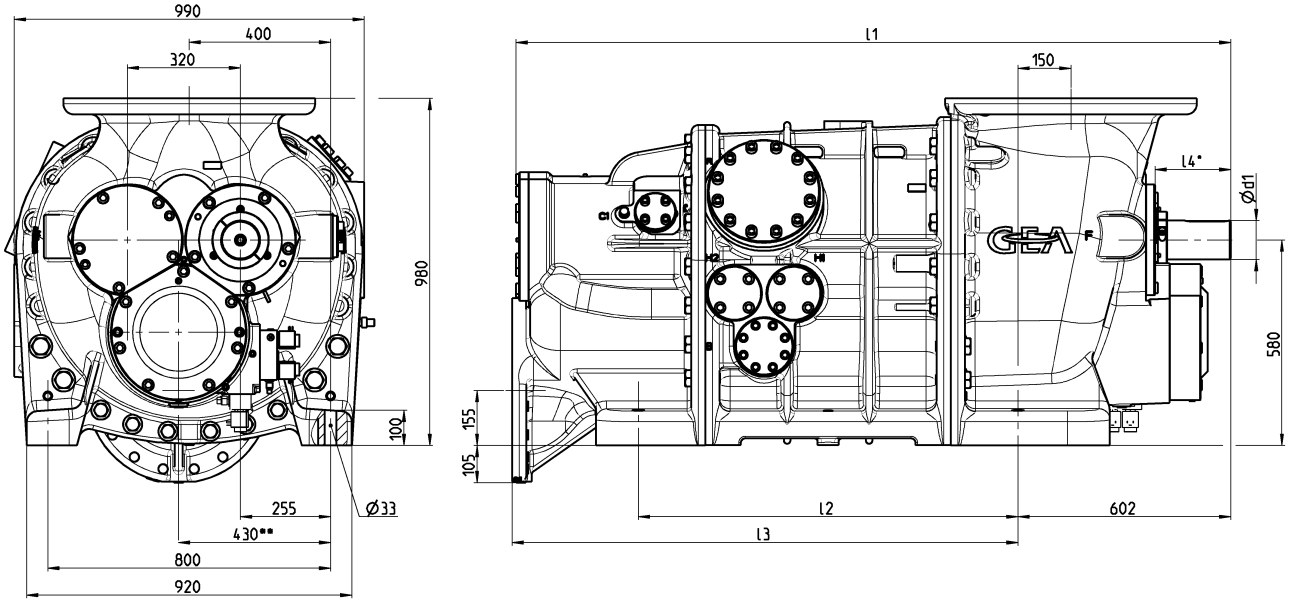


Fig.33

**	Position discharge connection

Coupling installation space

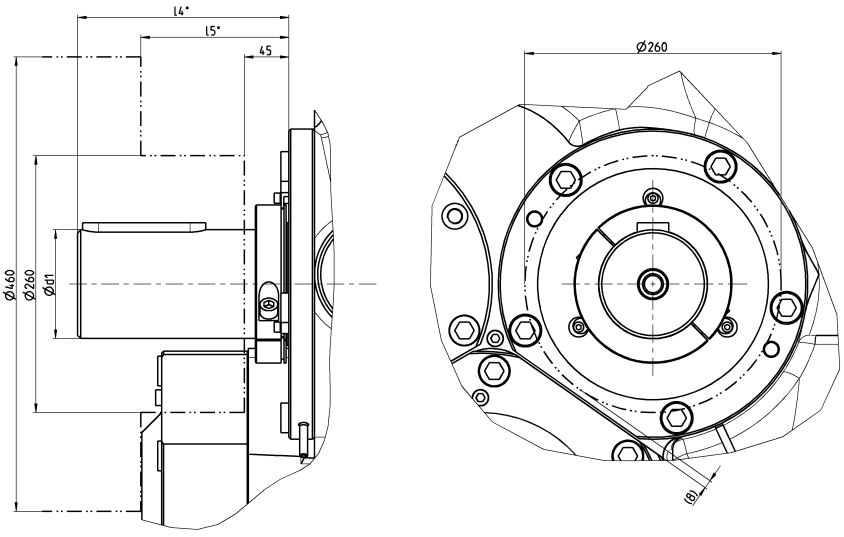


Fig.34

*	The dependence on the type of shaft seal used must be taken into account.

Main dimensions		Frame size	
		XG	**XH**
d1		Ø110 h6	
l1		2022	2140
l2		1074	1192
l3		1431	1549
l4*	Simple- GLRD	180	
	Double- GLRD	171 **/ 199 **	
l5*	Simple- GLRD	150	
	Double- GLRD	140	
approx. weight (kg) **		4900	5200

* The dependence on the type of shaft seal used and manufacturer must be taken into account.

** The value is applicable for a compressor with the compressor material cast steel without additional components.

This value varies depending on the housing material, the compressor design and the use of additional components.

8.8 Connections; frame sizes P, R, S, T, V, W, Y

P+I DIAGRAMM

Notice

Application instructions

► The type plate of each compressor is marked with the relevant P+I number of the screw compressor.
► The P+I diagram applies to the screw compressor only.
► The P+I diagram for the screw compressor only shows the connecting conditions to the screw compressor package.
► The P+I diagram of the screw compressor does not consider the piping scheme and the safety devices of the screw compressor package.
► The specified oil supply diagram of the compressor is part of the documentation and will be supplied with the compressor.

P+I diagrams are available for connecting the package oil circuit to the compressor, which will be determined based on the usage of the machines and have special labels.

PIPE CONNECTIONS / THREAD Frame size P

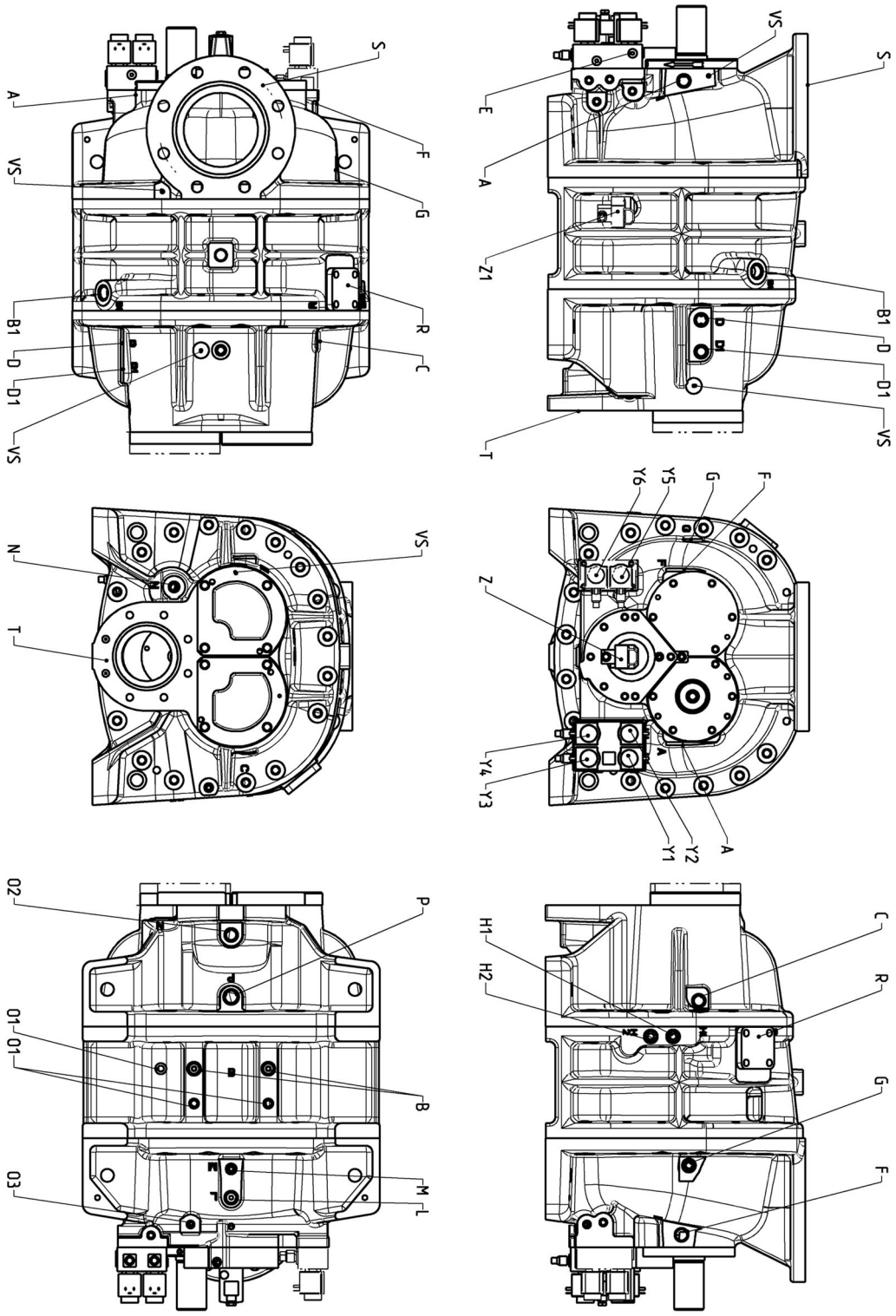


Fig.35: Connections, Frame size P

The description of the connections are included in tables on Page 142 and Page 147.

Frame size P			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle	-	DN 150 M24 x 30 *
T	Pressure nozzle	-	DN 100 M16 x 22 *
A	Oil-supply shaft seal, suct. side bearing	M22 x 1,5	
B	Oil injection compression chamber	M22 x 1,5	
B1	Additional oil injection compression chamber male rotor side	M26 x 1,5	
C	Oil-supply discharge side bearing, balance piston	M22 x 1,5	
C1	Special port axial bearing female rotor	-	
D	Oil-supply balance piston heat pump	M22 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G ¼	
F	Additional oil injection, Special oil injection suction housing	M22 x 1,5	
G	Special oil injection suction housing	M22 x 1,5	
H0	Refrigerant liquid injection (Suction pressure)	-	
H1	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H2	Refrigerant liquid injection (High pressure)	-	
L	Oil drain plug	M22 x 1,5	
M	Oil drain plug	M16 x 1,5	
N	Oil return separator	M16 x 1,5	
P	Gas pulsation protection	M26 x 1,5	
R	Economizer port, female rotor		DN 40 M12 x 25 *
R1	Economizer port, male rotor	-	
VS	Vibration sensor connection	¼ " -28 UNF x 10	
O1	Oil drain plug	M14 x 1,5	
O2	Oil drain plug	M22 x1,5	
O3	Oil drain plug	M12 x 1,5	

* Flange connection required; Flange thread: Thread diameter x Thread depth

PIPE CONNECTIONS / THREAD Frame sizes R, S, T

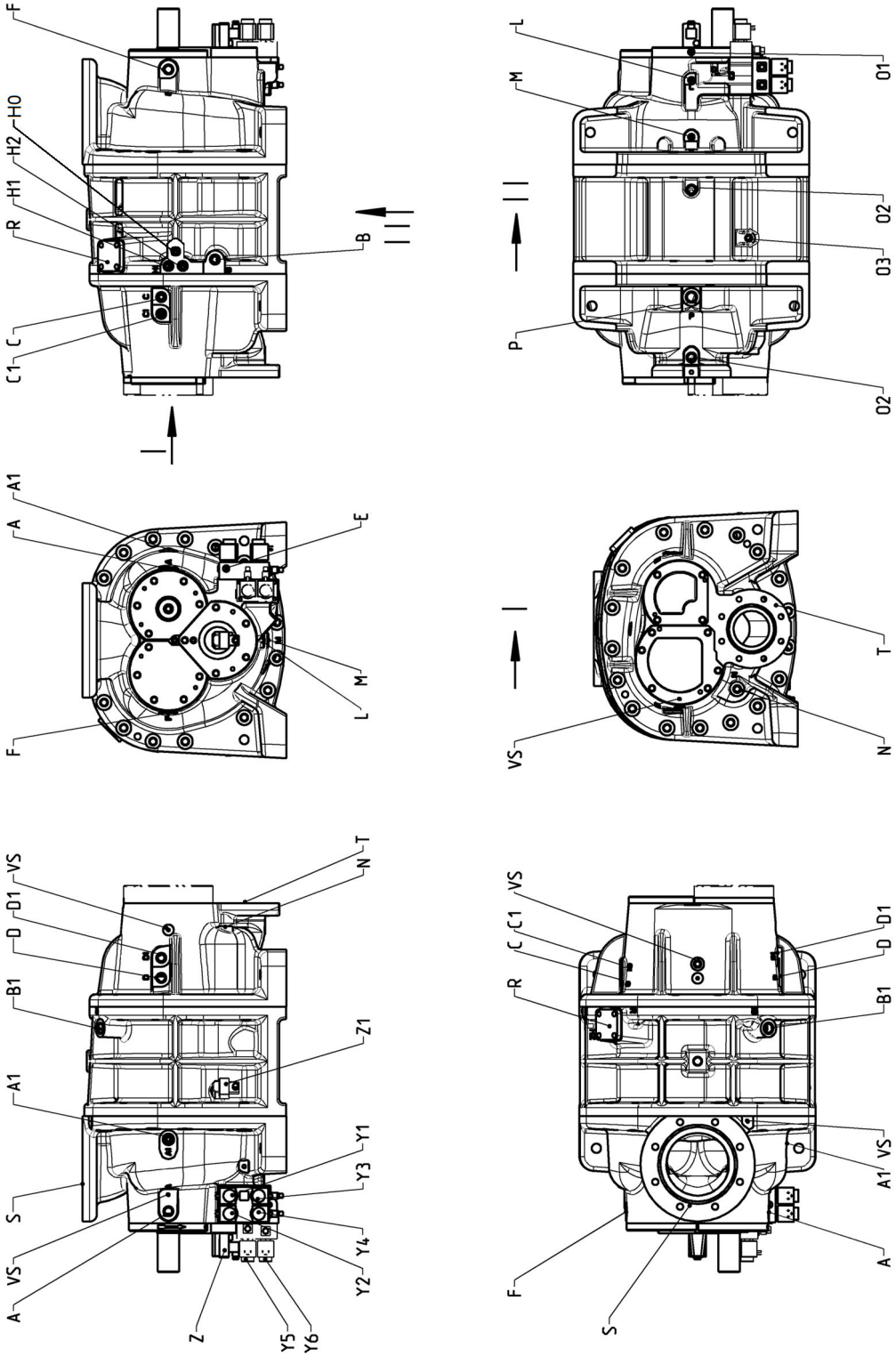


Fig.36: Connections, Frame sizes R, S, T

The description of the connections are included in tables on Page 144 and Page 147.

Frame sizes R, S, T			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle		DN 175 M20 x 30 *
T	Pressure nozzle		DN 100 M16 x 33 *
A	Oil-supply shaft seal, suct. side bearing	M22 x 1,5	
A1	Oil-supply suction side bearings (special design)	M22 x 1,5	
B	Oil injection compression chamber	M22 x 1,5	
B1	Additional oil injection compression chamber male rotor side	M26 x 1,5	
C	Oil-supply discharge side bearing, balance piston	M22 x 1,5	
C1	Special port axial bearing female rotor	M22 x 1,5	
D	Oil-supply balance piston heat pump	M22 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G ¼	
F	Additional oil injection, Special oil injection suction housing	M22 x 1,5	
H0	Refrigerant liquid injection (Suction pressure)	M22 x 1,5	
H1	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H2	Refrigerant liquid injection (High pressure)	M22 x 1,5	
L	Oil drain plug	M12 x 1,5	
M	Oil drain plug	M12 x 1,5	
N	Oil return separator	M16 x 1,5	
P	Gas pulsation protection	M26 x 1,5	
R	Economizer port, female rotor		DN 40 M12 x 25 *
VS	Vibration sensor connection	¼ " -28 UNF x 10	
O1	Oil drain plug	M22 x 1,5	
O2	Oil drain plug	M22 x 1,5	
O3	Oil drain plug	M14 x 1,5	

* Flange connection required; Flange thread: Thread diameter x Thread depth

PIPE CONNECTIONS / THREAD Frame sizes V, W, Y

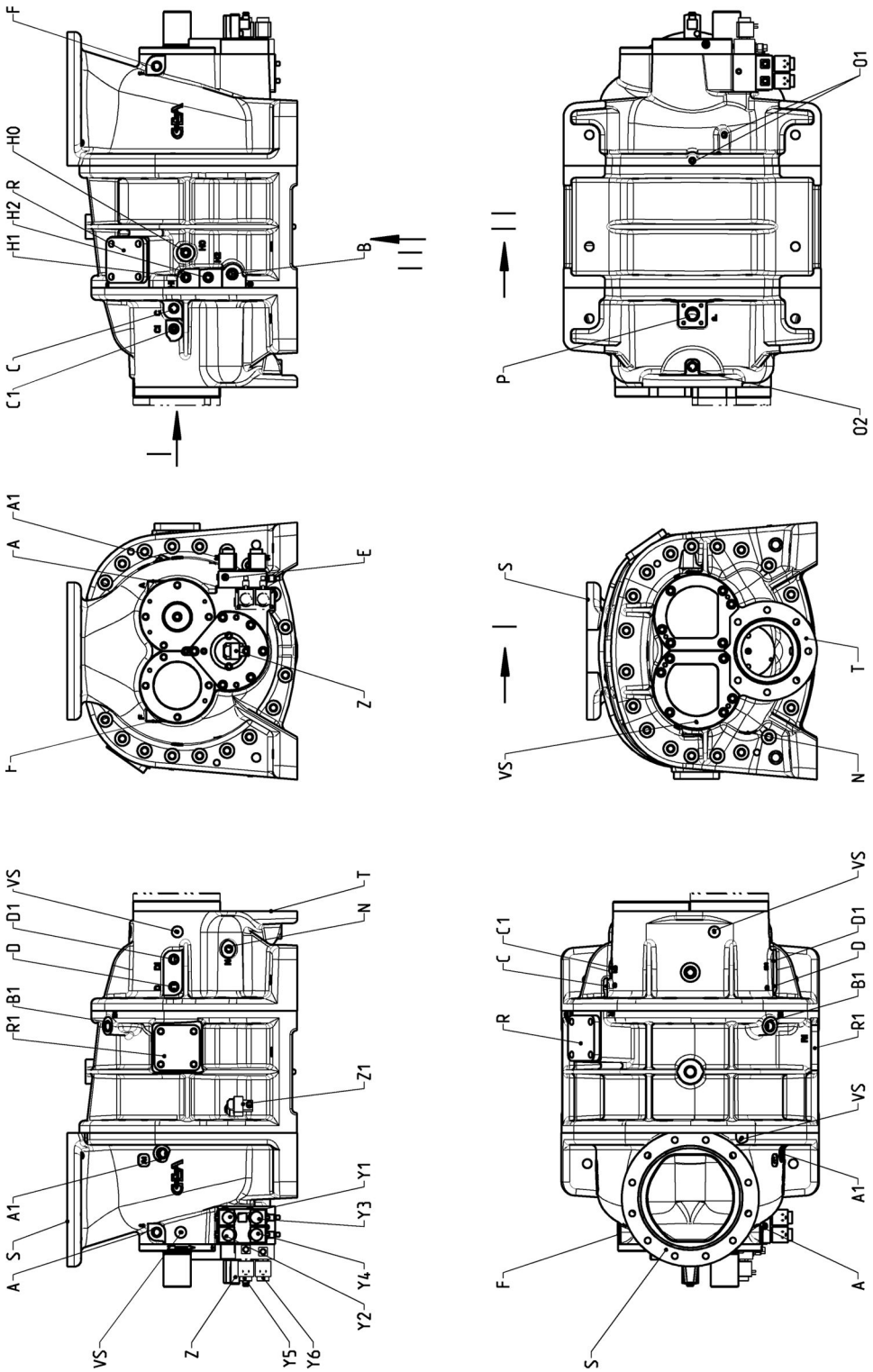


Fig.37: Connections, Frame sizes V, W, Y

The description of the connections are included in tables on Page 146 and Page 147.

Frame sizes V, W, Y			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle		DN 250 M20 x 40 *
T	Pressure nozzle		DN 150 M20 x 28 *
A	Oil-supply shaft seal, suct. side bearing	M22 x 1,5	
A1	Oil-supply suction side bearings (special design)	M22 x 1,5	
B	Oil injection compression chamber	M26 x 1,5	
B1	Additional oil injection compression chamber male rotor side	M26 x 1,5	
C	Oil-supply discharge side bearing, balance piston	M22 x 1,5	
C1	Special port axial bearing female rotor	M22 x 1,5	
D	Oil-supply balance piston heat pump	M22 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G ¼	
F	Additional oil injection, Special oil injection suction housing	M22 x 1,5	
H0	Refrigerant liquid injection (Suction pressure)	M22 x 1.5	
H1	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H2	Refrigerant liquid injection (High pressure)	M22 x 1,5	
N	Oil return separator	M16 x 1,5	
P	Gas pulsation protection	M33 x 2	DN 25 M10 x 20 *
R	Economizer port, female rotor		DN 65 M16 x 30 *
R1	Economizer port, male rotor		DN 65 M16 x 30 *
VS	Vibration sensor connection	¼ " -28 UNF x 10	
O1	Oil drain plug	M12 x 1,5	
O2	Oil drain plug	M22 x 1,5	

* Flange connection required; Flange thread: Thread diameter x Thread depth

ELECTRICAL CONNECTIONS

Connection	Purpose	Inlet	Outlet
Z	Position sensor for position display control slide/primary slide	24 V (DC)	4 - 20 mA
Z1	Position sensor for position display control slide stop	24 V (DC)	4 - 20 mA
Y1/Y4	Solenoid valves capacity control, direction of control, full-load	220 V/230 V AC 110 V AC 24 V DC 230 V / 240 V AC, ATEX 110 V / 120 V AC, ATEX 24 V DC, ATEX	
Y2/Y3	Solenoid valves capacity control, direction of control, part-load		
Y5	Solenoid valve variable Vi		
Y6	Solenoid valve variable Vi		

8.9 Connections; frame sizes Z, XA; XB, XC, XD; XE, XF

P+I DIAGRAMM

Notice

Application instructions

► The type plate of each compressor is marked with the relevant P+I number of the screw compressor.
► The P+I diagram applies to the screw compressor only.
► The P+I diagram for the screw compressor only shows the connecting conditions to the screw compressor package.
► The P+I diagram of the screw compressor does not consider the piping scheme and the safety devices of the screw compressor package.
► The specified oil supply diagram of the compressor is part of the documentation and will be supplied with the compressor.

P+I diagrams are available for connecting the package oil circuit to the compressor, which will be determined based on the usage of the machines and have special labels.

CONNECTION PORT / THREAD frame size Z

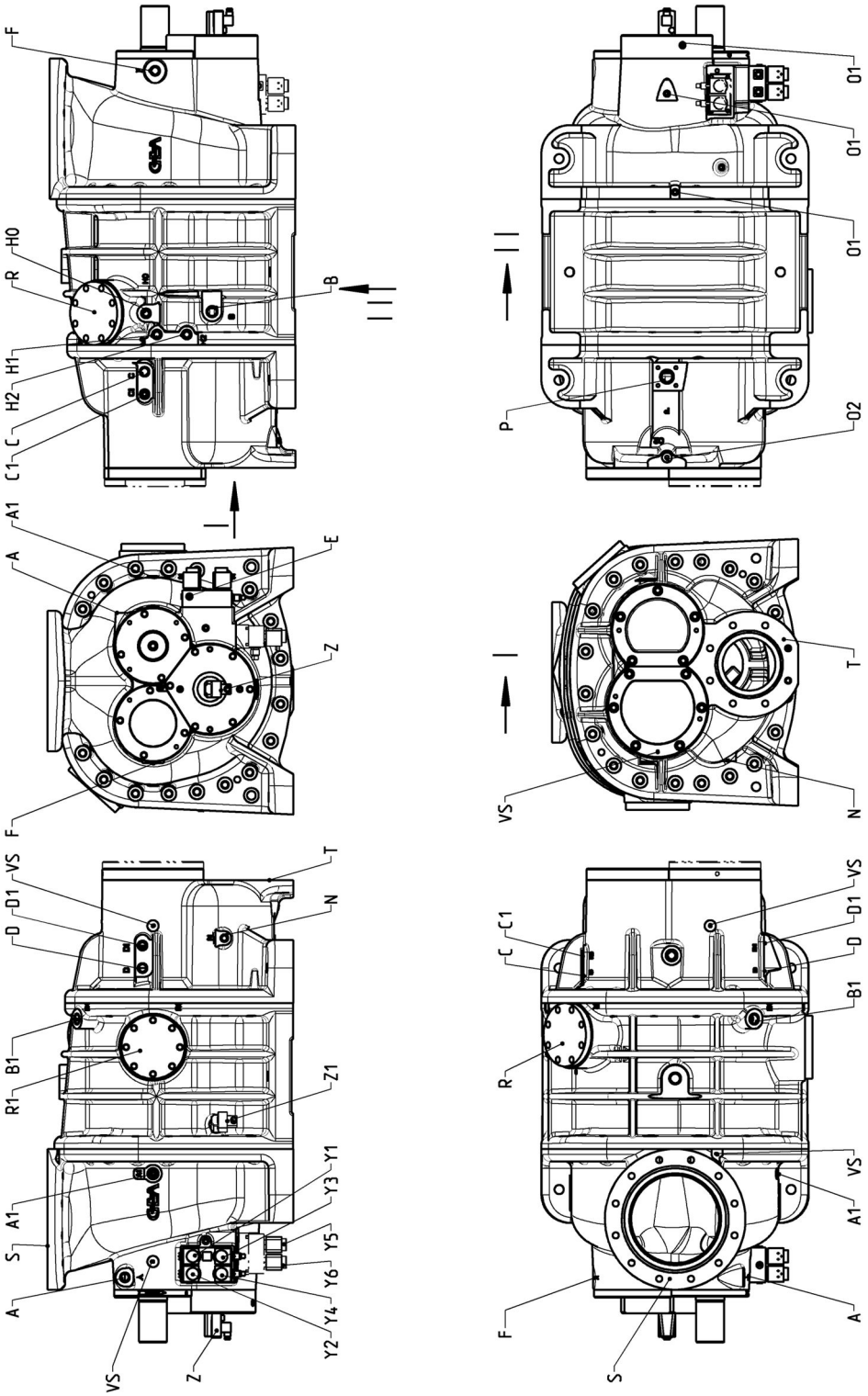


Fig.38: Frame size Z

The description of the connections are included in tables on Page 150 and Page 157.

Frame size Z			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle		DN 250 M20 x 45 *
T	Pressure nozzle		DN 150 M20 x 30 *
A	Oil-supply shaft seal, suction side bearing	M22 x 1,5	
A1	Oil-supply, suction side bearing (special design)	M22 x 1,5	
B	Oil injection compression chamber	M26 x 1,5	
B1	Additional oil injection compression chamber male rotor side	M26 x 1,5	
C	Oil-supply discharge side bearing, balance piston	M22 x 1,5	
C1	Special port axial bearing female rotor	M22 x 1,5	
D	Oil-supply balance piston heat pump	M22 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G 1/4	
F	Special oil injection suction housing	M22 x 1,5	
H0	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H1	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H2	Refrigerant liquid injection (High pressure)	M22 x 1,5	
N	Oil return separator	M16 x 1,5	
P	Gas pulsation protection	M33 x 2	DN 25 M10 x 30 *
R	Economizer port, female rotor		DN 80 M16 x 30 *
R1	Economizer port, male rotor		DN 80 M16 x 30 *
O1	Oil drain plug	M12 x 1,5	
O2	Oil drain plug	M12 x 1,5	
VS	Vibration sensor connection	¼ “ – 28 UNF x 8	

* Flange connection required; Flange thread: Thread diameter x Thread depth

PIPE PORT/ THREAD Frame size XA

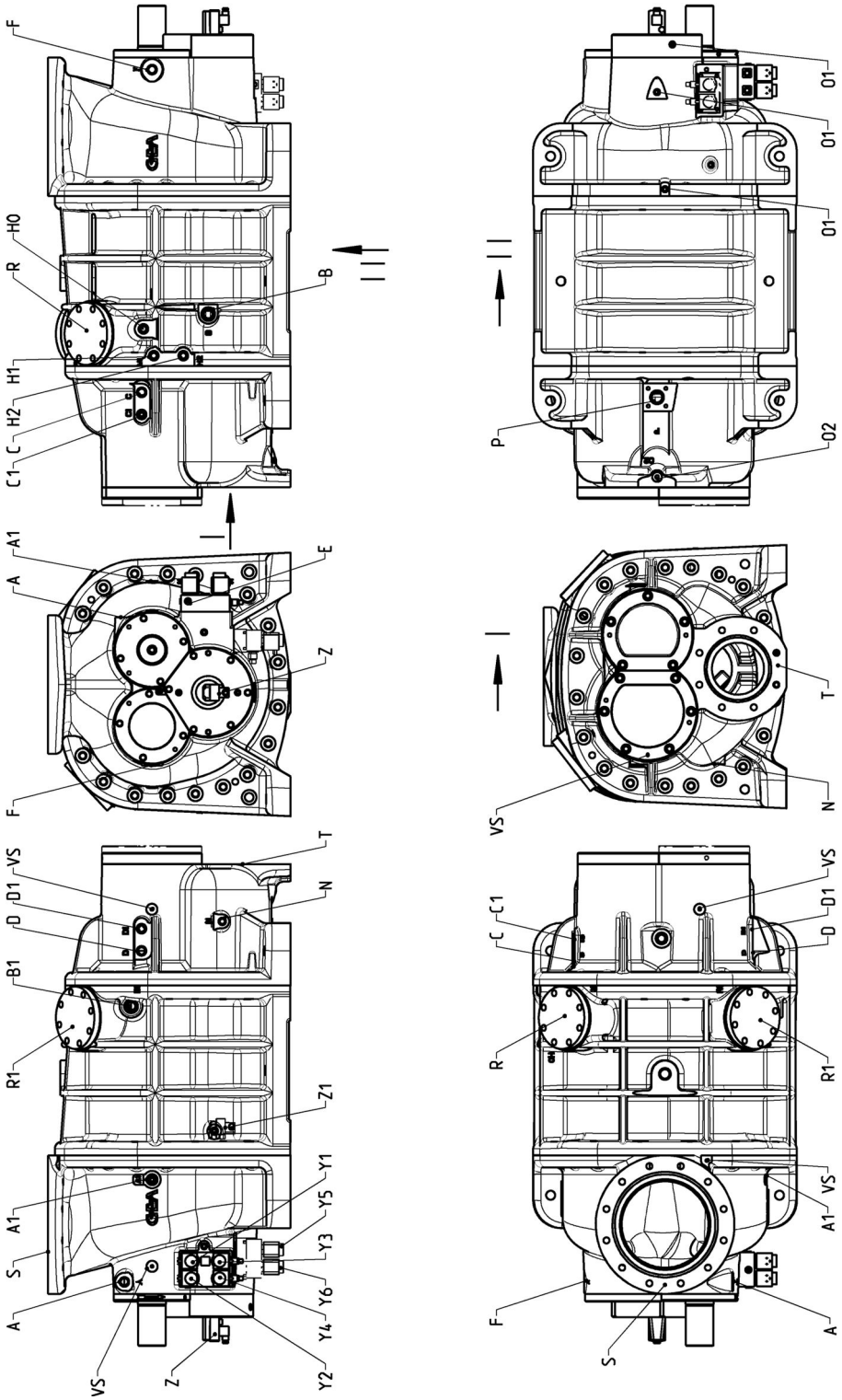


Fig.39: Frame size XA

The description of the connections are included in tables on Page 152 and Page 157.

PIPE PORT/ THREAD Frame size XA

Frame size XA			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle		DN 250 M20 x 45 *
T	Pressure nozzle		DN 150 M20 x 30 *
A	Oil-supply shaft seal, suction side bearing	M22 x 1,5	
A1	Oil-supply, suction side bearing (special design)	M22 x 1,5	
B	Oil injection compression chamber	M33 x 2	
B1	Additional oil injection compression chamber male rotor side	M33 x 2	
C	Oil-supply discharge side bearing, balance piston	M22 x 1,5	
C1	Special port axial bearing female rotor	M22 x 1,5	
D	Oil-supply balance piston heat pump	M22 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G 1/4	
F	Special oil injection suction housing	M22 x 1,5	
H0	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H1	Refrigerant liquid injection (Intermediate pressure)	M22 x 1,5	
H2	Refrigerant liquid injection (High pressure)	M22 x 1,5	
N	Oil return separator	M16 x 1,5	
P	Gas pulsation protection	M33 x 2	DN 25 M10 x 30 *
R	Economizer port, female rotor		DN 80 M16 x 30 *
R1	Economizer port, male rotor		DN 80 M16 x 30 *
O1	Oil drain plug	M12 x 1,5	
O2	Oil drain plug	M12 x 1,5	
VS	Vibration sensor connection	¼ " – 28 UNF x 8	

* Flange connection required; Flange thread: Thread diameter x Thread depth

PIPE CONNECTIONS/ THREAD Frame size XB, XC, XD

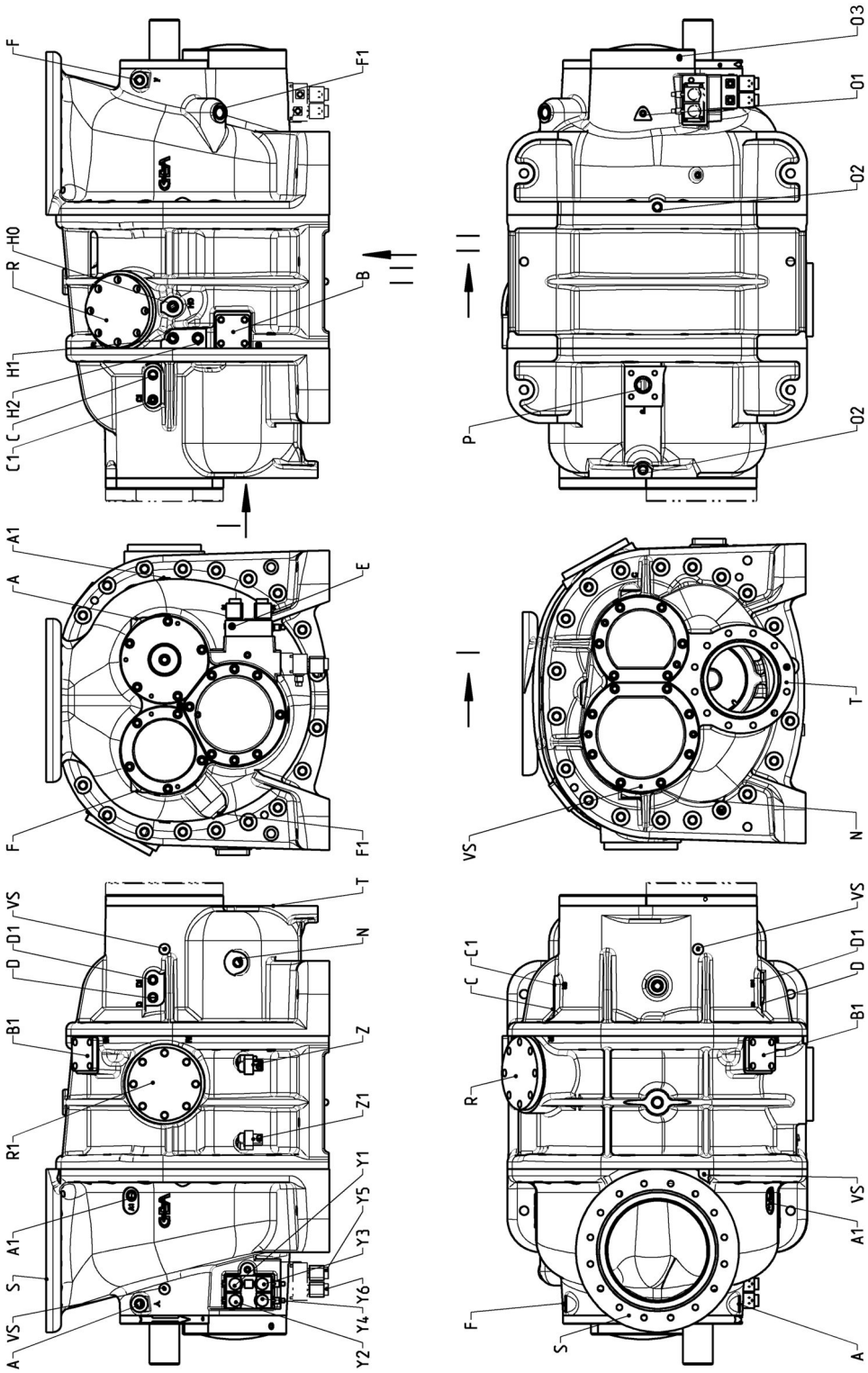


Fig.40: Frame size XB, XC, XD

The description of the connections are included in tables on Page 154 and Page 157.

PIPE CONNECTIONS/ THREAD Frame size XB, XC, XD

Frame size XB, XC, XD			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle		DN 300 M20 x 50 *
T	Pressure nozzle		DN 200 M20 x 32 *
A	Oil-supply shaft seal, suction side bearing	M22 x 1,5	
A1	Oil-supply, suction side bearing (special design)	M22 x 1,5	
B	Oil injection compression chamber		DN 50 M16 x 35 *
B1	Additional oil injection compression chamber male rotor side		DN 50 M16 x 35 *
C	Oil-supply discharge side bearing, balance piston	M22 x 1,5	
C1	Special port axial bearing female rotor	M22 x 1,5	
D	Oil-supply balance piston heat pump	M22 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G 1/4	
F	Special oil injection suction housing	M22 x 1,5	
F1	Special oil injection suction housing	M33 x 2	
H0	Refrigerant liquid injection (Intermediate pressure)	M26 x 1,5	
H1	Refrigerant liquid injection (Intermediate pressure)	M26 x 1,5	
H2	Refrigerant liquid injection (High pressure)	M26 x 1,5	
N	Oil return separator	M22 x 1,5	
P	Gas pulsation protection	M42 x 2	DN 35 M16 x 35 *
R	Economizer port, female rotor		DN 125 M20 x 40 *
R1	Economizer port, male rotor		DN 125 M20 x 40 *
O1	Oil drain plug	M12 X 1,5	
O2	Oil drain plug	M22 X 1,5	
O3	Oil drain plug	M16 X 1,5	
VS	Vibration sensor connection	¼ “ – 28 UNF x 8	

* Flange connection required; Flange thread: Thread diameter x Thread depth

PIPE CONNECTION / THREAD Frame size XE, XF

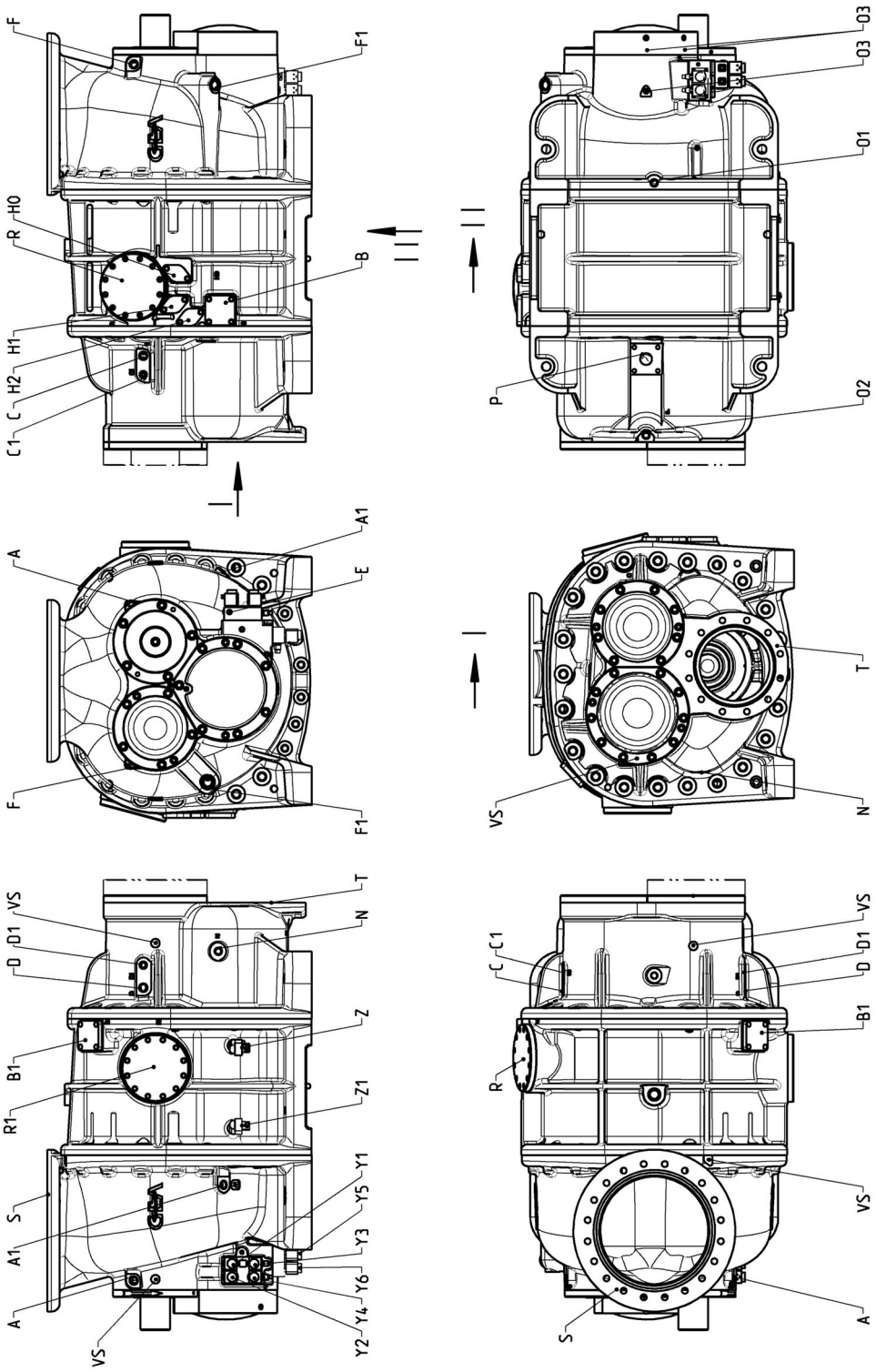


Fig.41: Frame size XE, XF

The description of the connections are included in tables on Page 156 and Page 157.

PIPE CONNECTION / THREAD Frame size XE, XF

Frame size XE, XF			
Connection	**Purpose**	**Screw joint Thread in housing**	**Flange connection Thread in flange**
S	Suction nozzle		DN 400 M24 x 48 *
T	Pressure nozzle		DN 250 M24 x 39 *
A	Oil-supply shaft seal, suction side bearing	M26 x 1,5	
A1	Oil-supply, suction side bearing (special design)	M26 x 1,5	
B	Oil injection compression chamber		DN 50 M16 x 34 *
B1	Additional oil injection compression chamber male rotor side		DN 50 M16 x 34 *
C	Oil-supply discharge side bearing, balance piston	M26 x 1,5	
C1	Special port axial bearing female rotor	M22 x 1,5	
D	Oil-supply balance piston heat pump	M26 x 1,5	
D1	Special port axial bearing male rotor	M22 x 1,5	
E	External oil-supply solenoid valve block for capacity control	G 1/4	
F	Special oil injection suction housing	M26 x 1,5	
F1	Special oil injection suction housing	M33 x 2	
H0	Refrigerant liquid injection (Intermediate pressure)		DN 25 M16 x 34 *
H1	Refrigerant liquid injection (Intermediate pressure)		DN 25 M16 x 34 *
H2	Refrigerant liquid injection (High pressure)		DN 25 M16 x 34 *
N	Oil return separator	M22 x 1,5	
P	Gas pulsation protection		DN 50 M16 x 30 *
R	Economizer port, female rotor		DN 150 M16 x 30 *
R1	Economizer port, male rotor		DN 150 M16 x 30 *
O1	Oil drain plug	M22 X 1,5	
O2	Oil drain plug	M22 X 1,5	
O3	Oil drain plug	M12 X 1,5	
VS	Vibration sensor connection	¼ " – 28 UNF x 8	

* Flange connection required; Flange thread: Thread diameter x Thread depth

ELECTRICAL CONNECTIONS

Connection	Purpose	Inlet	Outlet
Z	Position sensor for position display control slide/primary slide	24 V (DC)	4 - 20 mA
Z1	Position sensor for position display control slide stop	24 V (DC)	4 - 20 mA
Y1/Y4	Solenoid valves capacity control, direction of control, full-load	220 V/230 V AC 110 V AC 24 V DC 230 V / 240 V AC, ATEX 110 V / 120 V AC, ATEX 24 V DC, ATEX	
Y2/Y3	Solenoid valves capacity control, direction of control, part-load		
Y5	Solenoid valve variable Vi		
Y6	Solenoid valve variable Vi		

8.10 Connections; frame sizes XG, XH

P+I DIAGRAMM

Notice

Application instructions

► The type plate of each compressor is marked with the relevant P+I number of the screw compressor.
► The P+I diagram applies to the screw compressor only.
► The P+I diagram for the screw compressor only shows the connecting conditions to the screw compressor package.
► The P+I diagram of the screw compressor does not consider the piping scheme and the safety devices of the screw compressor package.
► The specified oil supply diagram of the compressor is part of the documentation and will be supplied with the compressor.

P+I diagrams are available for connecting the package oil circuit to the compressor, which will be determined based on the usage of the machines and have special labels.

PIPE CONNECTION / THREAD Size frame size XG, XH

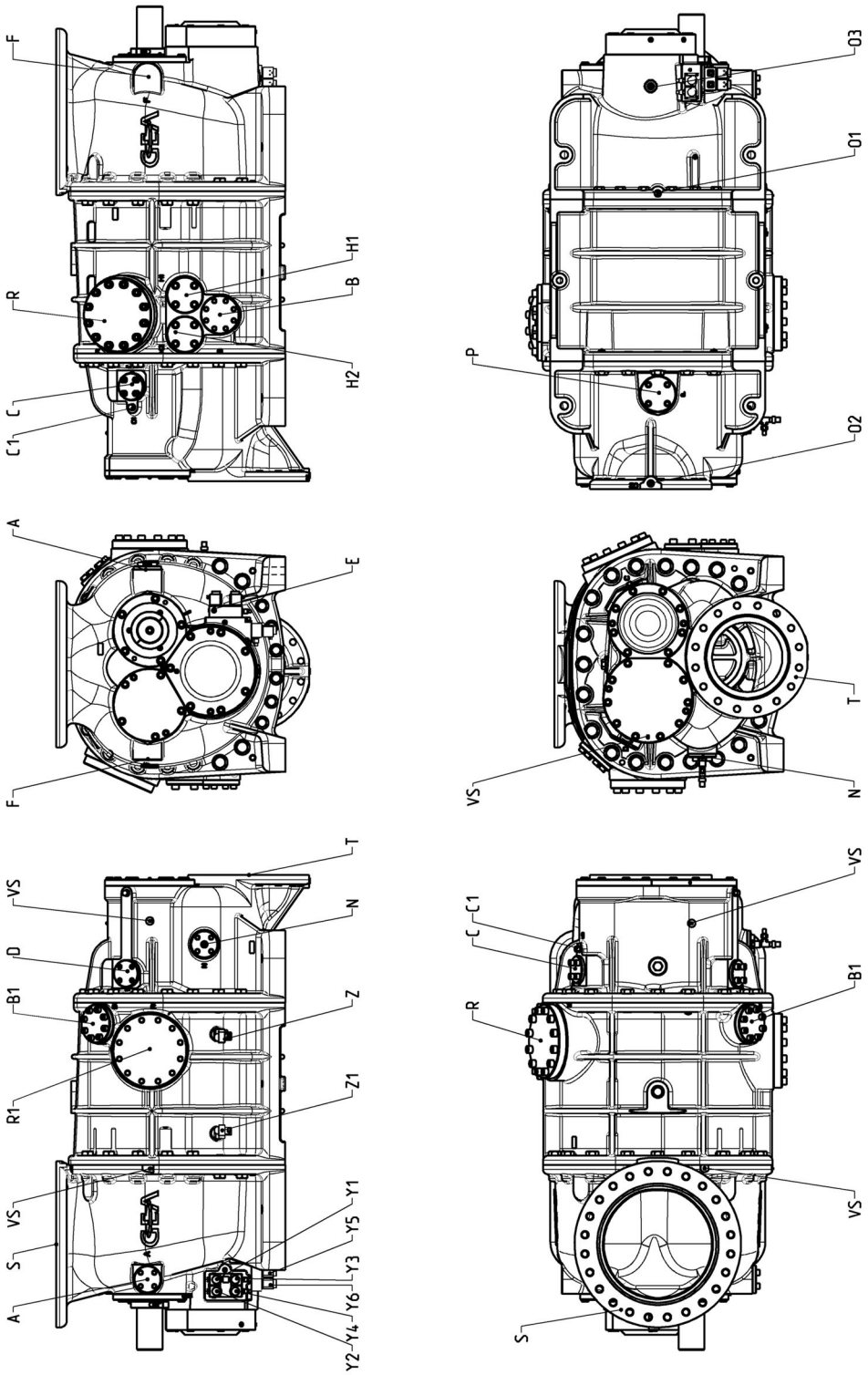


Fig.42: Frame size XG, XH

The description of the connections are included in tables on Page 160 and Page 161.

Frame size XG, XH				
Connection	**Purpose**	**Flange connection ASME Class: 300 lb**	**Flange connection Thread in flange**	**Screw joint Thread in housing**
S	Suction nozzle	18" *	M30 x 60 **	
T	Pressure nozzle	12" *	M30 x 45 **	
A	Oil-supply shaft seal, suction side bearing	¾" *	M16 x 32 **	
B	Oil injection compression chamber	2" *	M16 x 32 **	
B1	Additional oil injection compression chamber male rotor side	2" *	M16 x 32 **	
C	Oil-supply discharge side bearing, balance piston	¾" *	M16 x 32 **	
C1	Special port axial bearing female rotor			M22 x 1,5
D	Oil-supply balance piston heat pump	¾" *	M16 x 32 **	
D1***	Special port axial bearing male rotor			M22 x 1,5
E	External oil-supply solenoid valve block for capacity control			G 1/4
F***	Special oil injection suction housing	¾" *	M16 x 32 **	
H1	Refrigerant liquid injection (Intermediate pressure)	1 ½" *	M20 x 40 **	
H2	Refrigerant liquid injection (High pressure)	1 ½" *	M20 x 40 **	
N	Oil return separator	¾" *	M16 x 32 **	
P	Gas pulsation protection	1 ½" *	M20 x 40 **	
R	Economizer port, female rotor	6" *	M20 x 40 **	
R1	Economizer port, male rotor	6" *	M20 x 40 **	
O1	Oil drain plug			M22 X 1,5
O2	Oil drain plug			M22 X 1,5
O3	Oil drain plug			M22 X 1,5
VS	Vibration sensor connection			¼ “ 28 UNF x 8

* Flange connection: plain sealing face with O-ring groove.

** Flange connection required; Flange thread: Thread diameter x Thread depth

*** Connection only available if required.

ELECTRICAL CONNECTIONS

Connection	Purpose	Inlet	Outlet
Z	Position sensor for position display control slide/primary slide	24 V (DC)	4 - 20 mA
Z1	Position sensor for position display control slide stop	24 V (DC)	4 - 20 mA
Y1/Y4	Solenoid valves capacity control, direction of control, full-load	220 V/230 V AC 110 V AC 24 V DC 230 V / 240 V AC, ATEX 110 V / 120 V AC, ATEX 24 V DC, ATEX	
Y2/Y3	Solenoid valves capacity control, direction of control, part-load		
Y5	Solenoid valve variable Vi		
Y6	Solenoid valve variable Vi		

8.11 Conditions for Refrigerant Connections

Connection	Filter mesh size [µm]	Remarks
Suction nozzle upstream of the compressor	140 µm	
Pressure nozzle		During pressure compensation after stopping of the compressor, care should be taken to prevent foreign matter from getting into the compressor together with refrigerant vapour flowing back from the plant components arranged downstream of the compressor.
	140 µm	A filter can be used as an option.
Economizer connection upstream of the compressor	140 µm	Area of application between 140% and approx. 70% control slide position, depending on the refrigerant requirements. At economiser operation during part-load operation, care should be taken to maintain the projected intermediate pressure.
Refrigerant injection connection upstream of the compressor	140 µm	Refrigerant injection should only be used in conjunction with inertia-free temperature measurement on the compressor pressure side (time constant k < 10 sec). When operating with refrigerant injection, the regulating valve should be sized to ensure that no liquid refrigerant enters the oil separator downstream.

⚠ Caution!

Destruction of the filters and the compressor by suctioned liquids

Liquid (refrigerant or oil) can lead to destruction of the filter at the suction nozzle and economizer connection.

► Ensure that no liquids are suctioned.

Notice

Practical advice Design of the connection pipelines!

► Due to the screw compressors working principles, dynamic pressure points occur proportionally to the drive speed multiplied by the number of teeth on the male rotor on the connection with the screw compressor. These loads need to be included when designing the connection pipes.

Notice

Instruction for routing the pipe at the discharge connection

► The piping must be laid in such a way that liquids can drain freely from the compressor into the oil separator.

8.12 Conditions for oil connections; frame sizes P - XF

Compressor frame size	Function, purpose	Oil pump	Volume flow Q_{oil}		Oil pressure *) **) p_{oil}		t_{oil}	Oil viscosity V		Mesh size
			l/min		bar		°C	mm^2/s		
			min	max	min	max	max	min	max	
P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF	functional oil[1]	without / with	see hints Page 164		p + 0,5 [2]	p + 3,5 [3]	80	7	70	$\beta_{(15)} \geq 200$ [4] / $\beta_{(25)} \geq 200$ [5]
	Oil injection	without / with			p - 2,5 [2]	p + 3,5 [3]	100	1	70	≤ 140
	Capacity control	with	2	6	Chamber 1 [6] p + 0,5...3,5 Chamber 2 [6] p_0 + 7 Chamber 3 [6] p_0 + 4,5 [7]		80	1	70	$\beta_{(15)} \geq 200$ [4] / $\beta_{(25)} \geq 200$ [5]

p	Discharge pressure *[bar.g]*	p_{oil}	Oil pressure *[bar.g]*
p_0	Suction pressure *[bar.g]*	t_{oil}	Oil temperature *[°C]*
Q_{oil}	Volume flow rate oil *[l/min]*	V	Viscosity *[mm²/s] = [cSt]*

1) functional oil flow For bearings, cam seals, balance pistons, capacity control, Vi setting

2) The compressor must be switched off if this value falls below.

3) Reference value with oil pump. The compressor must be switched off if a value of p + 4.5 bar is exceeded.

4) in open processes (gas compression)

5) In closed processes (refrigeration)

6) Chambers 1,2 and 3 are defined in schematic diagram overleaf

7) if p - p_0 < 4,0 bar

*) Values may deviate depending on the operating conditions. The requirements in the manufacturer specifications for operating conditions need to be adhered to.

**) After start-up of the compressor drive motor, a failure of the oil pressure p_{oil} is permissible for 10 seconds within the first minute, and afterwards for 6 seconds.

Notice

Practical advice Design of the connection pipelines!

► Due to the screw compressors working principles, dynamic pressure points occur proportionally to the drive speed multiplied by the number of teeth on the male rotor on the connection with the screw compressor. These loads need to be included when designing the connection pipes.

Hints for the oil circuit

1. The manufacturer's compressor selection programme "RT-Select" should be used to select and check the screw compressor in relation to the application. The compressor selection program explains what operating conditions will require an external oil pump for the functional oil circuit (external oil pump required).
2. The oil volume flows needed to safely operate the compressor will be indicated in the compressor selection program based on operating conditions. The oil pump shall be measured so that the swept volume reaches the value of

   $V_{oil\ pump} = K \bullet V_{function\ oil}$.

   K= 1.25 for ammonia

   K = 1.4 for all other media to be pumped

   In the Grasso selection programme the terms

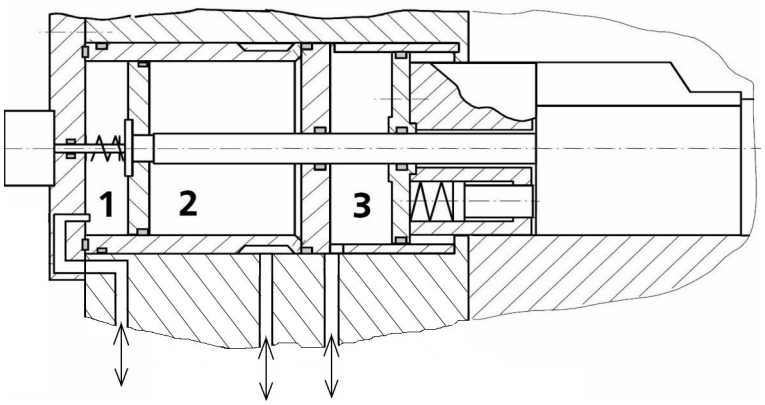
   - functional oil flow

   - total oil flow

   are used.
3. **LT Series**

   Hydraulic chambers for capacity control and Vi adjustment:

   The hydraulic chamber for capacity control and Vi adjustments shall be supplied via solenoid valve blocks that are flanged on the compressor housing. The pressures given in the tablePage 163 are guaranteed by the functional oil pressure and by regulating valves integrated in the blocks.



Schematic diagram: hydraulic chambers for capacity control and Vi adjustment.

Hydraulic chambers 1, 2 for capacity control

Hydraulic chambers 1, 2, 3 for combined Vi-partial load adjustment

8.13 Conditions for oil connections; frame sizes XG, XH

Compressor frame size	Function, purpose	Oil pump	Volume flow Q_{oil}		Oil pressure *) **) p_{oil}		t_{oil}	Oil viscosity V		Mesh size
			l/min		bar		°C	mm^2/s		
			min	max	min	max	max	min	max	
XG, XH	functional oil[1]	without / with	see hints Page 166		p + 0,5 [2]	p + 3,5 [3]	75	15	70	$\beta_{(15)} \geq 200$ [4] / $\beta_{(25)} \geq 200$ [5]
	Oil injection	without / with			p - 2,5 [2]	p + 3,5 [3]	100	1	70	≤ 140
	Capacity control	with	2	6	Chamber 1 [6] p + 0,5...3,5 Chamber 2 [6] p_0 + 7 Chamber 3 [6] p_0 + 4,5 [7]		75	1	70	$\beta_{(15)} \geq 200$ [4] / $\beta_{(25)} \geq 200$ [5]

p	Discharge pressure *[bar.g]*	p_{oil}	Oil pressure *[bar.g]*
p_0	Suction pressure *[bar.g]*	t_{oil}	Oil temperature *[°C]*
Q_{oil}	Volume flow rate oil *[l/min]*	V	Viscosity *[mm²/s] = [cSt]*

1) functional oil flow For bearings, cam seals, balance pistons, capacity control, Vi setting

2) The compressor must be switched off if this value falls below.

3) Reference value with oil pump. The compressor must be switched off if a value of p + 4.5 bar is exceeded.

4) For open processes (Gas compression), $\beta_{(15)} \geq 200$

5) For closed processes, $\beta_{(25)} \geq 200$

6) Chambers 1,2 and 3 are defined in schematic diagram overleaf

7) if $p - p_0 < 4{,}0$ bar

*) Values may deviate depending on the operating conditions. The requirements in the manufacturer specifications for operating conditions need to be adhered to.

**) After start-up of the compressor drive motor, a failure of the oil pressure p_{oil} is permissible for 10 seconds within the first minute, and afterwards for 6 seconds.

Notice

Practical advice Design of the connection pipelines!

► Due to the screw compressors working principles, dynamic pressure points occur proportionally to the drive speed multiplied by the number of teeth on the male rotor on the connection with the screw compressor. These loads need to be included when designing the connection pipes.

Hints for the oil circuit

1. The manufacturer's compressor selection programme "RT-Select" should be used to select and check the screw compressor in relation to the application. The compressor selection program explains what operating conditions will require an external oil pump for the functional oil circuit (external oil pump required).
2. The oil volume flows needed to safely operate the compressor will be indicated in the compressor selection program based on operating conditions. The oil pump shall be measured so that the swept volume reaches the value of

   $V_{oil\ pump} = K \bullet V_{function\ oil}$.

   K= 1.25 for ammonia

   K = 1.4 for all other media to be pumped

   In the Grasso selection programme the terms

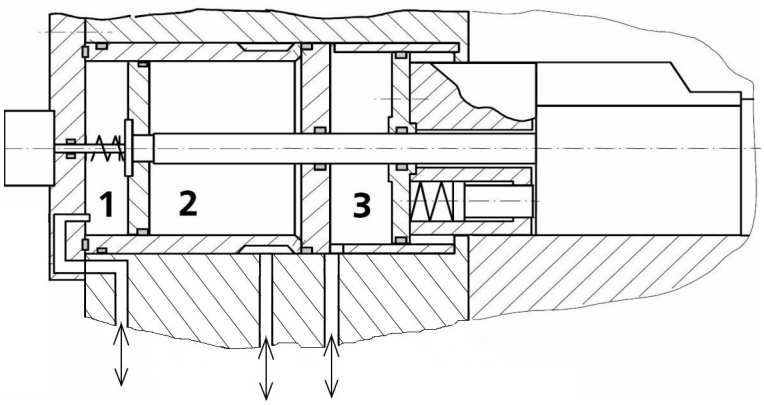
   - functional oil flow

   - total oil flow

   are used.
3. **LT Series**

   Hydraulic chambers for capacity control and Vi adjustment:

   The hydraulic chamber for capacity control and Vi adjustments shall be supplied via solenoid valve blocks that are flanged on the compressor housing. The pressures given in the tablePage 165 are guaranteed by the functional oil pressure and by regulating valves integrated in the blocks.



Schematic diagram: hydraulic chambers for capacity control and Vi adjustment.

Hydraulic chambers 1, 2 for capacity control

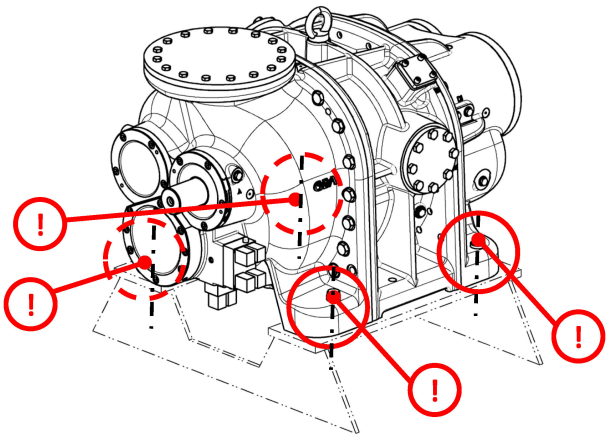
Hydraulic chambers 1, 2, 3 for combined Vi-partial load adjustment

8.14 Installation of the compressor

The compressor should be installed such that it is rigid on the package frame and is connected to it.

INSTALLATION CONDITIONS	
compressor mounting surface	- overall evenness of all mounting feet: 0.5 mm - support thickness: ≥ 25 mm

MOUNTING THE COMPRESSOR



Notice

Practical hint

► For the mechanical mounting of the screw compressor on the screw compressor package, an angle-compensating support such as a spherical washer-conical seat combination according to DIN 6319 has to be used, refer to Figure 43, Page 167. This spherical washer-conical seat combination is delivered with the compressor.
► The tightening torques given in table Page 167 must be observed during assembly.
► In the annual maintenance of the compressor, the fixing screws of the compressor must be re-tightened to the tightening torques given in table Page 167.

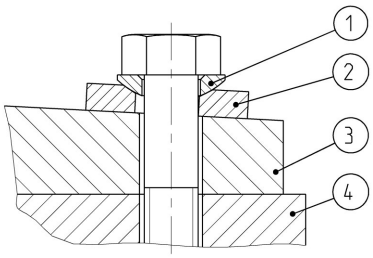


Fig.43: Spherical washer-conical seat combination

1 spherical washer
2 conical seat
3 screw compressor foot
4 compressor package (frame)

Required tightening torque of the mounting screws of the compressor		
Compressor frame size	**Screw**	**Tightening torque[1)][Nm]**
P, R, S, T, V, W, Y Z, XA XB, XC, XD	M24	730
XE, XF XG, XH	M30	1450
[1)] based on screw quality 8.8 and friction coefficient 0.14		

Drive motor, coupling

The drive motor shall be connected to the package frame via 3D-fixators.

The alignment of the drive motor to the compressor must be done according to the requirements of the coupling manufacturer. Familiarise yourself with the installation instructions of the coupling manufacturer and use them according to these instructions. The alignment of the drive motor must

be repeated after the initial assembly at operating temperature. Retain a logged record of the alignment.

8.15 Technical requirements for couplings

When using a coupling not supplied from the manufacturer the following conditions need to be met:

Parameter		Compressor frame size						
		P	**R, S, T**	**V, W, Y**	**Z, XA**	**XB, XC, XD**	**XE, XF**	**XG, XH**
Max. Driving power at 3600 rpm	kW	640	640	1500	1500	2160	3600	4193
Max. Driving power at 4500 rpm	kW	-	800	-	-	-	-	-
Nominal torque	Nm	1700	1700	4000	4000	5750	10440	11278
Max. Start-up: torque	Nm	4200	4200	10000	10000	14300	23500	25000
Max. Speed	rpm	3600	4500	3600				
maximum dynamic unbalance allowable	gcm	40			50	60	70	70
permissible radial force F_R [1)]	N	900		1300	1400	1500	1600	1600
permissible axial force F_A	N	400		600	600	800	800	800
shaft diameter Compressor	mm	60 h6		80 h6	80 h6	90 h6	110 h6	110 h6
min. distance between Shaft ends compressor/motor[2)]	mm	70 $^{+5}$		80 $^{+5}$	80 $^{+5}$	80 $^{+5}$	90 $^{+5}$	90 $^{+5}$

[1)] Permissible forces that may impact the compressor shaft end. The selection of coupling and the orientation are to be set up so that this force is not exceeded.

[2)] Values apply to simply functioning mechanical shaft seals (Standard). When using double mechanical seals contact needs to be made with manufacturer.

The maximum permitted drive capacities listed are upper limits determined by the drive shaft ends. Due to wear on the bearings, these drive forces shall not be achieved within a compressor size for all the available flow volumes. The review will be carried out in the compressor selection program.

Further conditions:	
design of the compressor shaft end:	cylindrical ATEX type compressors. cylindrical with featherkey.
attachment of the compressor shaft end:	by means of a firmly tightened clamping joint; Compressor in ATEX type: Non-positive stack assembly with additional adjustment springs.
Direction of rotation:	clockwise and counter clockwise
Start up and shut down frequency	maximum 10 per hour
operating temperature range:	- 20 °C to + 55 °C for dynamic operating load

8.16 Vibrations, sound, allowed pipe forces; frame sizes P - XF

Vibrations			
Main exciter frequency	**Speed**		
	3000 min^{-1}	**3600 min^{-1}**	**4500 min^{-1}**
f[1]	50	60	75
f[2]	100	120	150
f[3]	250	300	375
f[4]	500	600	750

Speeds greater than 3600 min^{-1} Only for compressor frame sizes R, S, T.

Balance grade	
Balance grade of rotors	**Compressor frame size**
	P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF
Balance grade G (mm/s) acc. DIN ISO 21940	G 2,5

Vibration limit values	
Compressor frame size	**Effective vibration speed/ RMS [1)]** **in frequency range A between 10 Hz and 1000 Hz[2)]**
	Permissible limit value (mm/s)[3)4)5)6)]
P, R, S, T	6.0
V, W, Y, Z, XA	7.0
XB, XC, XD	8.0
XE, XF	9.0

1) Measuring method according to DIN ISO 10816.

2) Frequency range to be measured minimum up to 1000 Hz, above 4000 min^{-1} minimum up to 1500 Hz

3) In case of rigid installation of compressor.

4) The installation of compressor as well as the design of frame and pipes of the package must be considered so that the limit values of vibration velocity do not overlap.

5) Limit values apply up to 3000 min^{-1}. For speeds from 3600 min^{-1} and higher, the limit values are to be multiplied with 1.2.

6) The expected value of effective vibration speed during trouble-free continuous operation is 50% of the above mentioned limit value with optimal frame design

Recommended monitoring limits:

WARNING: 75…100% of the permissible limit value

SWITCH-OFF: 115…140% of the permissible limit value

Notice

Practical note: Limit values standstill monitoring, standstill measurement

If the effective vibration velocity measured at standstill is more than 25% of the specified limit value:

► Reduce the influence of the spurious oscillations.
► Avoid sudden excitations.

Mass moment of inertia, torsional stiffness of the compressor rotor pair

Notice

Regulation torsion analysis drive train

► Careful mechanical design and construction of the compressor package.
► Carry out a torsional analysis of the drive train to ensure safe operation outside the critical torsional natural frequencies.

The values of the mass moment of inertia and torsional stiffness of the compressor rotor pair required for the torsional analysis are provided in the following table. These values apply for compressors with a maximum discharge pressure of 28 bar in the compressor versions “B”, “S”, “R”. Values for deviating compressor designs are deposited with the manufacturer.

Values for torsion analysis							
	Compressor frame size						
	P	R	S	T	V	W	Y
Mass moment of inertia [kg m^2]	0.280	0.446	0.556	0.625	0.903	1.055	1.236
Torsional stiffness [kNm/rad]	510	470	470	470	1108	1108	1108

Values for torsion analysis							
	Compressor frame size						
	Z	XA	XB	XC	XD	XE	XF
Mass moment of inertia [kg m^2]	1.778	2.08	4.09	4.73	5.52	9.76	11.57
Torsional stiffness [kNm/rad]	975	975	1789	1789	1789	3530	3530

Sound

Emitted sound values								
		Compressor frame size						
		P	R	S	T	V	W	Y
Sound power level L_{WA}	dB (A)	88	89	90	90	91	91	92
Emission sound pressure level L_{pA}	dB (A)	74	75	76	76	76	77	77

Emitted sound values								
		Compressor frame size						
		Z	XA	XB	XC	XD	XE	XF
Sound power level L_{WA}	dB (A)	93	94	96	97	98	99	100
Emission sound pressure level L_{pA}	dB (A)	78	79	81	82	83	83	84

The sound power of the compressor depends on its capacity and varies with the operating conditions of the unit. The sound emitted is caused by the compression process, gas pulsations and vibrations. The noise level is influenced strongly by the interaction between the compressor and the compressor unit. In practice, the sound power levels may deviate from the stated values.

The specifications apply exclusively for the following operating conditions with a fluctuation range of ± 3 dB:

- Speed n=2900 ... 3100 min^{-1}
- Oil temperature 45…55°C
- Medium NH3 (R717)
- Operating points t_0/t_c [°C]: 5/50; -10/45; -35/40; without economiser
- Operating points p_0/p_c [bar.a]: 5,2/20,3; 2,9/17,8; 0,96/15,5; without economiser

The internal volume ratio must correspond to the optimum Vi value calculated in the compressor selection programme for the specified operating point.

The emission sound pressure level L_{pA} at a distance of 1 m from the machine surface (A-close range sound level at open air conditions on reflecting surface) is a table value reduced by 13 to 17 dB(A) compared to the sound power level L_{WA}.

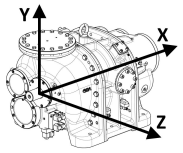
L_{WA}: A-weighted sound power level according to DIN EN ISO 9614-2 and DIN 45635, reference 1 pW

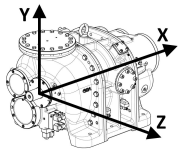
L_{pA}: A-weighted emission sound pressure level at 1m distance according to DIN EN ISO 11203, reference 20 µPa

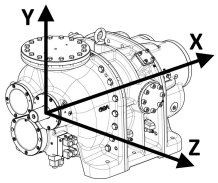
Notice

Notes on the pipe design

► Due to the working principle of the screw compressor, dynamic pressure points occur at the connections of the screw compressor, particularly at the pressure nozzle, at a frequency that is proportional to the drive speed multiplied by the number of teeth of the male rotor.
► The design of the connecting pipelines must consider the critical pipe lengths depending on the speed of sound, in order to avoid resonances.
► The sound emission of the package is significantly influenced by such pressure pulsations in the pipes.

PERMISSIBLE PIPING FORCES AND MOMENTS including gas forces									
maximum permissible Pressure	**Point of application**		**Vector** 	**Compressor frame size**					
				P	**R/S/T**	**V/W/Y**	**Z/XA**	**XB/XC/XD**	**XE/XF**
28 bar	Suction nozzle: Screw Strength class A2-70	force [N]	|x|	2100	2500	3400	3400	4000	6000
			$\|y_{max}\|$	5300	6200	8800	8500	10000	14500
			$\|y_{min}\|$	-5300	-6200	-8800	-8500	-10000	-17000
			|z|	3400	4000	5200	5200	6000	7500
		Torque [Nm]	|x|	3800	2000	4250	4250	5100	7400
			|y|	2200	2500	3700	3750	4200	6800
			|z|	1700	2000	3200	3000	4000	6000
	Discharge nozzle: Screw Strength class 8.8	force [N]	|x|	3300	3300	2100	3200	3000	5200
			|y|	3450	3450	5500	5300	7200	8400
			|z|	3300	3300	3400	3400	4600	5200
		Torque [Nm]	|x|	1500	1500	2800	2800	3700	4300
			|y|	1500	1500	2200	2200	2900	3700
			|z|	1500	1500	2000	1900	2500	3100
	Eco socket: Screw Strength class A2-70	force [N]	|x|	300	300	1000	2300	1750	2100
			|y|	400	400	1000	2300	4350	5300
			|z|	300	300	1000	2300	2900	3400
		Torque [Nm]	|x|	100	100	450	1100	2420	1800
			|y|	100	100	450	1100	1700	2150
			|z|	200	200	550	1200	1500	1800

PERMISSIBLE PIPING FORCES AND MOMENTS including gas forces									
maximum permissible Pressure	**Point of application**		**Vector** 	**Compressor frame size**					
				P	**R/S/T**	**V/W/Y**	**Z/XA**	**XB/XC/XD**	**XE/XF**
52 bar	Suction nozzle: Screw Strength class A2-70	force [N]	|x|	2100	1700	1400	1400	2000	5800
			$\|y_{max}\|$	5260	4000	5000	5000	2000	14500
			$\|y_{min}\|$	-5260	-4000	-5000	-7700	-10000	-17000
			|z|	3400	1700	1400	1400	2000	7500
		Torque [Nm]	|x|	3460	1200	1500	1500	1150	3100
			|y|	2150	900	1000	1000	1150	6800
			|z|	1700	1200	1500	1500	1150	5500
	Discharge nozzle: Screw Strength class 8.8	force [N]	|x|	3000	3000	2100	3200	3000	5200
			|y|	3450	3450	5500	5300	7200	8400
			|z|	3000	3000	3400	3400	4600	5200
		Torque [Nm]	|x|	1200	1200	1800	2800	3700	4300
			|y|	1300	1300	1800	2200	2900	3700
			|z|	1300	1300	1800	1900	2500	3100
	Eco socket: Screw Strength class A2-70	force [N]	|x|	300	300	700	1500	1750	2000
			|y|	400	400	700	1500	4350	3000
			|z|	300	300	700	1500	2900	2000
		Torque [Nm]	|x|	100	100	300	900	1300	1000
			|y|	100	100	300	900	1300	1000
			|z|	200	200	500	1200	1500	1800

PERMISSIBLE PIPING FORCES AND MOMENTS including gas forces							
maximum permissible Pressure	**Point of application**		**Vector** 	**Compressor frame size**			
				R/S/T	**V/W/Y**	**Z/XA**	**XB/XC/XD**
63 bar	Suction nozzle: Screw Strength class A2-70	force [N]	|x|	1000	900	900	2000 *)
			$\|y_{max}\|$	2700	1400	1700	2000 *)
			$\|y_{min}\|$	-2700	-4000	-7700	-10000 *)
			|z|	1000	900	900	2000 *)
		Torque [Nm]	|x|	800	400	400	1150 *)
			|y|	600	400	400	1150 *)
			|z|	800	400	400	1150 *)
	Discharge nozzle: Screw Strength class 8.8	force [N]	|x|	3000	2100	2100	3000
			|y|	3450	5500	5300	7200
			|z|	3000	3400	3400	4600
		Torque [Nm]	|x|	1100	1500	1900	3700
			|y|	1100	1500	1900	2900
			|z|	1100	1500	1900	2500
	Eco socket: Screw Strength class A2-70	force [N]	|x|	300	600	1450	1750
			|y|	300	600	1450	4350
			|z|	300	600	1450	2900
		Torque [Nm]	|x|	100	200	800	1200
			|y|	100	200	800	1200
			|z|	150	400	1050	1500

*) screws of strength class 8.8 are required

8.17 Vibrations, sound, permissible piping loads; frame sizes XG, XH

Vibrations		
Main excitation frequencies	**Speed**	
	3000 rpm	**3600 rpm**
f^1	50	60
f^2	100	120
f^3	250	300
f^4	500	600

Balance grade	
Balance grade of rotors	**Compressor frame size**
	XG, XH
Balance grade G (mm/s) acc. DIN ISO 21940	G 2,5

Vibration limit values	
Compressor frame size	**Effective vibration velocity/ RMS [1)]** **in frequency range A between 10 and 1000 Hz [2)]**
	Permissible limit value (mm/s)[3)4)5)6)]
XG, XH	10.0

1) Measuring method according to DIN ISO 10816.

2) Frequency range to be measured, minimum up to 1000 Hz; above 4000 rpm, minimum up to 1500 Hz

3) In case of rigid installation of compressor.

4) The installation of compressor as well as the design of frame and pipes of the package must be considered so that the limit values of vibration velocity do not exceed.

5) Limit values are valid up to 3000 rpm. For a speed of 3600 rpm and higher the limit value must be multiplied by 1.2.

6) The expected value of effective vibration velocity during trouble-free continuous operation is 50% of the above mentioned limit value with optimal frame design.

Recommended monitoring limits:

WARNING: 75... 100% of the permissible limit value

SHUTDOWN: 115...140% of the permissible limit value

Notice

Practical note: Limit values standstill monitoring, standstill measurement

If the effective vibration velocity measured at standstill is more than 25% of the specified limit value:

► Reduce the influence of the spurious oscillations.
► Avoid sudden excitations.

Mass moment of inertia, torsional stiffness of the compressor rotor pair

Notice

Prescription Torsional analysis of drive train

► Careful mechanical design and construction of the compressor unit.
► Performance of a torsional analysis of the drive train to ensure safe operation outside the critical torsional natural frequencies.

The values of the mass moment of inertia and torsional stiffness of the compressor rotor pair required for the torsion analysis are given in the table below. The values are valid for compressors with a maximum discharge pressure of 28 bar in compressor designs "B", "S", "R". Values for different compressor designs can be obtained from the manufacturer.

Values for torsional analysis		
	Compressor frame size	
	XG	XH
Mass moment of inertia [kg m^2]	13.35	15.50
Torsional stiffness [kNm/rad]	2732	2732

Sound

Emitted sound values			
		Compressor frame size	
		XG	XH
Sound power level L_{WA}	dB (A)	101	102
Emission sound pressure level L_{pA}	dB (A)	85	85

The sound power of the compressor depends on its capacity and varies with the operating conditions of the plant. The emitted sound is caused by the compression process, gas pulsations and vibrations. The noise level is strongly influenced by the interaction between the compressor and the compressor package. In practice, the sound power levels may differ from the specified values.

The indicated values apply only for the following operating conditions with a variation of ± 3 dB:

- Speed n=2900 ... 3100 rpm
- Oil temperature 45...55 °C
- Medium NH3 (R717)
- Operating points t_0/t_c [°C]: 5/50; -10/45; -35/40; without economizer
- Operating points p_0/p_c [bar.a]: 5,2/20,3; 2,9/17,8; 0,96/15,5; without economizer

The inner volume ratio must be the best Vi value calculated in the compressor selection program for the specified operating point.

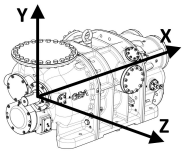
The emission sound pressure level L_{pA} in dB(A) at a distance of 1 m from the machine surface (A near level with free field conditions on a reflective base area) is a table value reduced by 13 to 17 dB(A) compared to the sound power level L_{WA}.

L_{WA}:	A-weighted sound power level according to DIN EN ISO 9614-2 and DIN 45635, reference: 1 pW
L_{pA}:	A-weighted emission sound pressure level at 1 m distance according to DIN EN ISO 11203, reference: 20 µPa

Notice

Practical advice Design of the connection pipelines!

► Due to the working principle of the screw compressor, dynamic pressure points occur at the connections of the screw compressor, particularly at the pressure nozzle, at a frequency that is proportional to the drive speed multiplied by the number of teeth of the male rotor.
► The design of the connecting pipelines must consider the critical pipe lengths depending on the speed of sound, in order to avoid resonances.
► The sound emission of the package is significantly influenced by such pressure pulsations in piping systems.

PERMISSIBLE PIPING FORCES AND TORQUES: including gas forces				
Maximum permitted pressure	**Point of application**		**Vector** 	**Compressor frame size** **XG/ XH**
28 bar	Suction nozzle: Screw Strength class A2-70	Force [N]	|x|	7000
			$\|y_{max}\|$	16300
			$\|y_{min}\|$	-25000
			|z|	8500
		Torque [Nm]	|x|	9700
			|y|	7200
			|z|	7200
	Discharge nozzle: Screw Strength class 8.8	Force [N]	|x|	6000
			|y|	10000
			|z|	6000
		Torque [Nm]	|x|	5100
			|y|	4200
			|z|	4200
	Eco nozzle: Screw Strength class A2-70	Force [N]	|x|	2100
			|y|	5300
			|z|	3400
		Torque [Nm]	|x|	2800
			|y|	2200
			|z|	1900

8.18 Operating limits; frame sizes P - XH

The compressor and the installed components are designed for specific operating conditions which must be maintained for safe working of the compressor.

⚠ Caution!

Damage to the compressor and compressor package

► The following specified minimum and maximum limit values must be adhered to.
► The design-related maximum pressure as per the nameplate must not be exceeded.
► Beyond that, project-specific restrictions or limit values, which must be agreed separately, apply.

Process parameters		**Operation limits**	
Permissible pressure (EN 378) (Gauge pressure)	p	max	28 bar / 52 bar, according to the nameplate
Suction temperature [24]	t_{0h}	min	- 60 °C
Discharge temperature	t_e	max	120°C
Pressure ratio	p_c / p_0	min	1.5
		max	22
Pressure difference	p_c - p_0	min	0.8
Function oil pressure [25]	p_{oil}	min *	p_c + 0,5 bar [26]
		max *	$_c$ + 3.5 bar (standard value) [27]
Oil temperature	t_{oil}	min	18°C
		max	80°C
Oil viscosity	v	min	7 mm^2/s (cSt) 15 mm^2/s (cSt) at XG, XH
		max	70 mm^2/s (cSt)
Suction filter mesh	W_s	max	140 µm
Mesh size Oil	W_{oil}	max	15 µm (function oil) in open processes (gas compression) • $\beta_{(15)} \geq 200$ 25 µm (function oil) in closed processes • $\beta_{(25)} \geq 200$
			140 µm injection oil

* process parameters which must be monitored with the compressor control, including warning and switch-off values for the compressor unit.

24 A dry-saturated steam has to be ensured during the suction process (no liquid).
25 measured between oil pump and compressor
26 If the value falls below the value, the compressor must be shut-down.
27 The compressor must be shut-down if a value of p + 4.5 bar is exceeded.

Ambient conditions	
Ambient temperature	**Value range / to be observed**
Start-up Compressor	+5 °C ... +45 °C **Notice** Requirements on the minimum ambient temperature to avoid compressor damage. ► The minimum ambient temperature of 5°C must be reached at least 12 hours before start-up of the compressor.
Compressor operation	-20 °C ... +45 °C

Drive parameters								
Compressor frame size		**P**	**R/ S/ T**	**V/ W/ Y**	**Z/ XA**	**XB/ XC/ XD**	**XE/ XF**	**XG/ XH**
max. Drive power (kW) at	3000 rpm	530	530	1250	1250	1800	3280	3472
	3600 rpm	640	640	1500	1500	2160	3940	4193
	4500 rpm	-	800	-	-	-	-	-
max. Nominal torque *)	Nm	1700	1700	4000	4000	5750	10440	11278
max. Permissible speeds	rpm	3600	4500	3600	3600	3600	3600	3600
min. Permissible speed	rpm	1500	1500	1500	1500	1500	1500	1500

*) When running the compressor with a non-electrical drive, the maximum torque is reduced by 25%.

Notice

Application instructions
► All requirements in chapters “Operating limits”, “Installation” and following requirements must be fulfilled to guarantee a save operation of the compressor.

Compressors for a discharge pressure up to 52 bar are equipped with housings made of a material of higher strength and are fitted with special components.
Minimum suction overheating in compressor inlet: "wet" operation has to be avoided.
For $\Delta p = p_c - p_o \leq 4$ bar for compressors of LT series with Vi-adjustment, a functional oil pressure of $p_{oil} \geq p_0 + 4{,}5$ bar needs to be guaranteed.
For $\pi \geq 8$ gas vibration protection is required.
For the use of CO_2 in the compressors of all types, depending on the operating conditions it has to be verified the use of a full-flow oil pump for injection oil and functional oil; for types Z to XH depending on the operating conditions it has to be verified the use of a full-flow oil pump or a partial-flow oil pump for functional oil.
The discharge temperature t_e must be 10 K above the condensing temperature t_c ($t_e \geq t_c + 10$ K).
Due to the solubility of refrigerant in the oil following applies:

- for Ammonia:
  - **$t_e \geq t_{oil} + 5$ K**;
  - **$t_e \geq t_{oil} + 10$ K**, when using a PAG oil (dissolving of refrigerant in the oil).
- For R22, R134a, R404A, R407C, R410A, R507, CO_2, natural gas, hydrocarbon compounds:
  - **$t_e \geq t_{oil} + 10$ K**, when refrigerant is dissolved in the oil.

→ **To determine the permitted difference between the discharge temperature (t_e) and oil intake temperature (t_{oil}), the set viscosity and the solubility diagram for the refrigerant-oil pair from the lubrication supplier need to be adhered to.**

Ensure that the oil viscosity is 7...70 cSt for the oil supply to the bearings (frame sizes XG, XH: ≥15...70 cSt). Take into account the drop in viscosity due to refrigerant dissolved in the oil!
Limits for temperature differences will be considered in compressor selection programs.
The oil temperature at the compressor inlet must be at least 18°C, the oil must be preheated if necessary.
The rate of temperature change at compressor suction side should not exceed 0,1 K/s.
Rotation direction: view of compressor’s driving shaft clockwise.
For individual cases outside the permitted speed coordination needs to made with the manufacturer.

p_c	Condensing pressure / Discharge pressure	t_{0h}	Suction temperature (compressor inlet)
p_0	Suction pressure	t_e	Discharge temperature (compressor outlet)
Δp	Pressure difference ($p_c - p_0$)	t_c	Condensing temperature
π	Pressure ratio (p_c/p_0)	t_{oil}	oil inlet temperature into the compressor

Notes:

1. During tests of a certain application case, all the conditions specified in the table must be considered and adhered to.
2. Should the given limits not be adhered to in individual cases, the manufacturer needs to be consulted.
3. In addition to the application limits stated in the tables, the applicable operating conditions of the compressor in question must also be considered (e. g. start-up regime, oil pressure, oil quantity, etc.).
4. Depending on the refrigeration requirements, economiser operation takes place at a control slide position between 100% and approx. 70%.
5. If **R134a** is used as a refrigerant with **condensation temperature of > 60 °C** the manufacturer needs to be contacted.

8.19 Start-up, frame sizes P - XH

8.19.1 Initial operation

Notice

General requirements for the initial start-up of the compressor

► Before initial operation, the compressor must be checked by a specialist.
► Check the turning direction of the drive motor when the coupling is removed.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Carry out a pressure test according to the Installation and Maintenance Manual.
► Carry out a vacuum test according to the Installation and Maintenance Manual.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that safe supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF LT SERIES (TYPES P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG, XH):

1. **Control slider in MIN position**
   - Solenoid valve controls Y2 and Y3 when the compressor comes with a solenoid valve block.
     Energise solenoid valve Y2/Y3 if the compressor is equipped with a directional control valve block, minimum direction of control.
   - Starting the external oil pump to push control slide towards minimum.
   - At start up, the current signal from the position sensor of the control slide must be: 4...5 mA (0%...6%).
2. **Time sequence and limitations**
   - Start the oil pump prior to start-up the compressor
   - Only when both the required Minimum position of the control slide and the oil pressure have been reached within the first 15 sec after start-up of the oil pump is it permitted to start the compressor drive motor.
   - Should the flows not be achieved in this time, the oil pump will continue to operate for up to 180 seconds until both lines are filled. The start-up of the drive motor immediately afterwards is not allowed.

3. **Oil pressure**
   - For oil pressure see the "Operating parameters / limit values" section.
   - Before starting the compressor use the control to check:
     - the minimum and maximum oil differential pressure.
     - the maximum oil pressure.
   - After start-up of the compressor drive motor, a failure of the oil pressure p_{oil} is permissible for 10 seconds within the first minute, and afterwards for 6 seconds.
4. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18 °C at an oil viscosity of ≤ 70 cSt ("Operating parameters / limit values" section).

Notice

Damage of the compressor due to oil filling of the working chamber.

► A break-time of 600 seconds after the oil pump is switched off is required if the start attempt is between 15 seconds and 180 seconds. Only after this the oil pump may be started again and the drive motor may be put into operation.
► The compressor is filled with oil that drains out within the 600-second break.
► If the oil pump keeps running for more than 180 sec., an additional start-up is forbidden.
► An error message will be displayed in the compressor control system.
► Search for the source of the error.

STOP CONDITIONS

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

8.19.2 Start-up after long standstill period

Notice

General information on the safe start-up.

► Before start-up after long standstill periods, the compressor must be checked by instructed operating personnel.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF LT SERIES (TYPES P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG, XH):

1. **Control slider in MIN position**
   - Solenoid valve controls Y2 and Y3 when the compressor comes with a solenoid valve block.
     Energise solenoid valve Y2/Y3 if the compressor is equipped with a directional control valve block, minimum direction of control.
   - Starting the external oil pump to push control slide towards minimum.
   - At start up, the current signal from the position sensor of the control slide must be: 4...5 mA (0%...6%).
2. **Time sequence and limitations**
   - Start the oil pump prior to start-up the compressor
   - Only when both the required Minimum position of the control slide and the oil pressure have been reached within the first 15 sec after start-up of the oil pump is it permitted to start the compressor drive motor.
   - Should the flows not be achieved in this time, the oil pump will continue to operate for up to 180 seconds until both lines are filled. The start-up of the drive motor immediately afterwards is not allowed.

3. **Oil pressure**
   - For oil pressure see the "Operating parameters / limit values" section.
   - Before starting the compressor use the control to check:
     - the minimum and maximum oil differential pressure.
     - the maximum oil pressure.
   - After start-up of the compressor drive motor, a failure of the oil pressure p_{oil} is permissible for 10 seconds within the first minute, and afterwards for 6 seconds.
4. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18 °C at an oil viscosity of ≤ 70 cSt ("Operating parameters / limit values" section).

Notice

Damage of the compressor due to oil filling of the working chamber.

► A break-time of 600 seconds after the oil pump is switched off is required if the start attempt is between 15 seconds and 180 seconds. Only after this the oil pump may be started again and the drive motor may be put into operation.
► The compressor is filled with oil that drains out within the 600-second break.
► If the oil pump keeps running for more than 180 sec., an additional start-up is forbidden.
► An error message will be displayed in the compressor control system.
► Search for the source of the error.

STOP CONDITIONS

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

8.19.3 Automatic operation (start-stop operation)

Notice

General information on the safe start-up.

► Before start-up after long standstill periods, the compressor must be checked by instructed operating personnel.
► Turn the compressor manually on the drive shaft when currentless drive motor and mounted coupling to verify the functionality of the compressor.
► Make sure that the compressor is both mechanically and electrically in order and is fully connected.
► Make sure that the compressor is connected to all necessary media. To do this, also compare the P+I diagram entered on the type plate with the documentation belonging to the compressor.
► Immediately before start-up, make sure that supply with all required media is possible. Open all necessary manually operated shut-off valves according to the P + I diagram of the package.

Notice

General information on the use of refrigerant-soluble oils.

► For Initial operation and for start-up after longer periods of standstill or maintenance of the compressor, sufficient mixture of refrigerant and oil is to be provided before the start-up of the screw compressor package since the high viscosity of the unmixed oil leads to bearing damage.

STARTING CONDITIONS FOR COMPRESSORS OF LT SERIES (TYPES P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG, XH):

1. **Control slider in MIN position**
   - Solenoid valve controls Y2 and Y3 when the compressor comes with a solenoid valve block.
     Energise solenoid valve Y2/Y3 if the compressor is equipped with a directional control valve block, minimum direction of control.
   - Starting the external oil pump to push control slide towards minimum.
   - At start up, the current signal from the position sensor of the control slide must be: 4...5 mA (0%...6%).
2. **Time sequence and limitations**
   - Start the oil pump prior to start-up the compressor
   - Only when both the required Minimum position of the control slide and the oil pressure have been reached within the first 15 sec after start-up of the oil pump is it permitted to start the compressor drive motor.
   - Should the flows not be achieved in this time, the oil pump will continue to operate for up to 180 seconds until both lines are filled. The start-up of the drive motor immediately afterwards is not allowed.

3. **Oil pressure**
   - For oil pressure see the "Operating parameters / limit values" section.
   - Before starting the compressor use the control to check:
     - the minimum and maximum oil differential pressure.
     - the maximum oil pressure.
   - After start-up of the compressor drive motor, a failure of the oil pressure p_{oil} is permissible for 10 seconds within the first minute, and afterwards for 6 seconds.
4. **Oil temperature**
   - The oil temperature upstream of the compressor must be at least 18 °C at an oil viscosity of ≤ 70 cSt ("Operating parameters / limit values" section).

Notice

Damage of the compressor due to oil filling of the working chamber.

► A break-time of 600 seconds after the oil pump is switched off is required if the start attempt is between 15 seconds and 180 seconds. Only after this the oil pump may be started again and the drive motor may be put into operation.
► The compressor is filled with oil that drains out within the 600-second break.
► If the oil pump keeps running for more than 180 sec., an additional start-up is forbidden.
► An error message will be displayed in the compressor control system.
► Search for the source of the error.

STOP CONDITIONS

Before stopping the compressor, the slide must be moved into the MIN position.

Notice

Specifications for operation with an external oil pump.

► When using an **external oil pump** for oil supply of the compressor, the oil pump has**to stop with** at the same time of the drive motor **out of service** drive motor.

Notice

Requirement for operation with frequency converter

► When using a speed-controlled drive with frequency converter, the stop, parameterized in the frequency converter, has to be set to **"Free Wheel"** / **“Free run-out”** .

Switch-on blocking time (Start to Start)

Notice

Damage to the compressor from short switch-on intervals.

► The minimum switch-on blocking time, time between two starts, must **be at least 600 sec** if the manufacturer of the drive motor requires no higher switch-on blocking time.

Forced break (Stop to Start)

Notice

Damage to the compressor from short stop intervals.

► The minimum compulsory break, stationary after compressor stop, must **be at least 10** seconds.

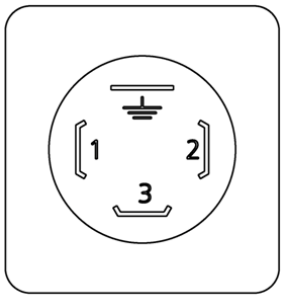
9 ELECTRICAL CONNECTIONS

Position sensors / Single valves / Valve blocks

Part	Connection value	Output signal	Purpose	Compressor Frame size
Position sensor	24 V (DC)	4-20 mA	Position indicator Control slide (primary slide) Position indicator control slide limitation (secondary slide)	C, D, E, G H, L, M, N, P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG, XH
Single valves	24 V (DC) 24 V (AC) 110 V (50/60 Hz) 220/230 V (50/60 Hz) 230/ 240 V (50/60 Hz) ATEX* 110/120 V (50/60 Hz) ATEX*	-	Operating the capacity control Operating the combined Vi part-load adjustment Operating the suction-side check valve (hot gas valve)	C, D, E, G, H, L, M, N,
Valve block 2 Valve block 4			Operates capacity control with valve block 4 or combined Vi – part load adjustment with valve block 2 and 4	P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG, XH
directional control valve block	24 V (DC) ATEX, UL 110 V (50/60 Hz) ATEX, UL 230/ 240 V (50/60 Hz) ATEX	-	Operating the capacity control	P, R, S, T, V, W, Y, Z, XA, XB, XC, XD, XE, XF, XG, XH
			Operating the combined Vi part-load adjustment	

The coils marked with * must be protected against UV radiation and against moisture.

Position sensor connection diagram



Connection set up:
1: Voltage. 24V DC
2: Neutral wire - 0V DC
3: Signal output, 4 - 20 mA
⏚ not assigned

Output signal:

Min. pos. Control slide	4 mA
Max. pos. Control slide	20 mA
Control slide limitation	4 mA
Position min:	20 mA
Position max.:	

Fig.44: Position sensor connection diagram

⚠ Caution!

Application instruction!

► The operation of Grasso screw compressors with variable Vi is permitted only if the compressor-control-software is based on the algorithm for Vi-adjustment defined by Grasso.

SOLENOID VALVES
connection diagram

Valve block 4
Installed on compressors from the LT series

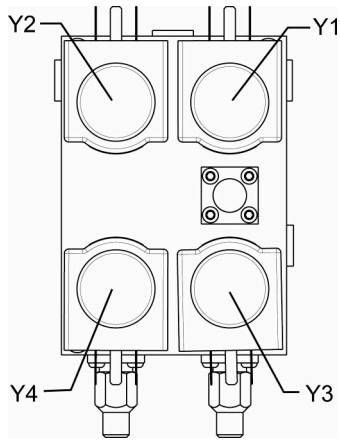


Fig.45: Valve block 4

Valve block 2
Only on compressors with variable Vi from the LT series

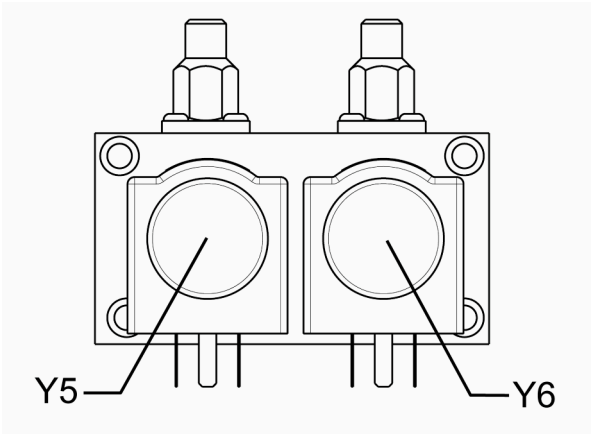


Fig.46: Valve block 2

LT Series

Valve block 4 for Vi setting Series LT, in combination with valve block 2, at full load (Mode 3)

Vi increase: Primary slide moves in direction discharge side:	Y2 and Y3 opened Y1 and Y4 closed
Vi reduction: Primary slide moves in direction suction side:	Y1 and Y4 open Y2 and Y3 closed

Partial-load operating mode: (Mode 1)	Y5 open Y6 closed
Partial-load operating mode: (Mode 2) At reduction capacity secondary slide moves in direction suction side	Y5 open Y6 closed
At increase capacity secondary slide moves in direction discharge side	Y5 closed Y6 open
Full-load operating mode: (Mode 3) Secondary slide is displaced with primary slide in the Vi setting	Y5 closed Y6 open

Alternative solution for frame sizes XB, XC, XD, XE, XF, XG, XH:
Directional valve blocks for capacity control and optional Vi-adjustment

Directional valve block capacity control

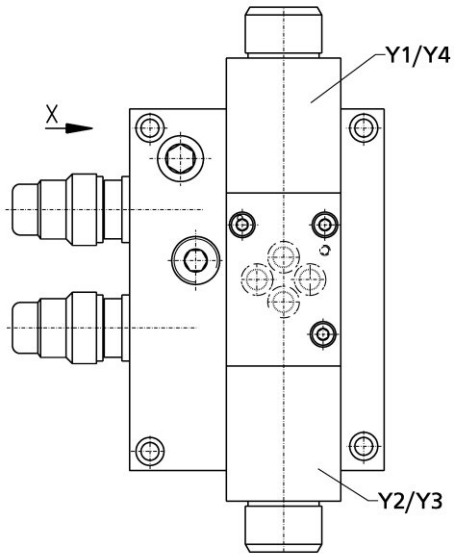


Fig.47: Connection diagram directional control valve block capacity control

Capacity control

Control direction MAX:	Y1/Y4	open
	Y2/Y3	closed
Control direction MIN:	Y2/Y3	open
	Y1/Y4	closed

Directional control valve block Vi position

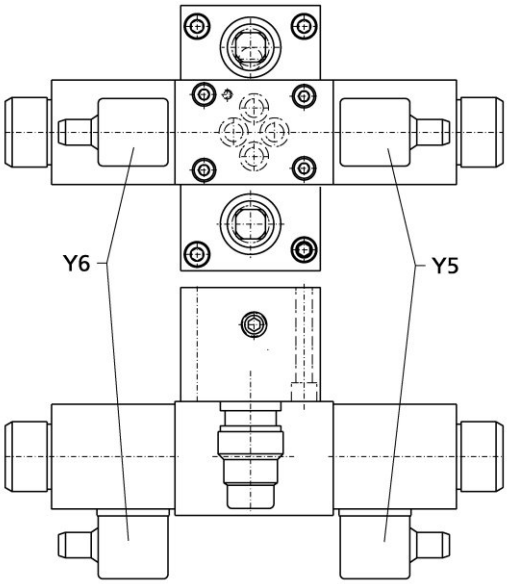


Fig.48: Connection diagram directional control valve block Vi position

Combined Vi-/ part load control

Capacity control in the upper part load operation:

Capacity increase	Y5	closed
	Y6	open
capacity reduction:	Y5	open
	Y6	closed

Vi position at full capacity

	Y6	generally open
	Y5	generally closed
Vi-increase	Y2/Y3	open
	Y1/Y4	closed
Vi-reduction	Y2/Y3	closed
	Y1/Y4	open

10 OPERATING DATA MONITORING

⚠ Caution!

Personal injury and damage to property due to non-compliance with the application limits!

► Compressors may only be run between the prescribed usage parameters.

► The limits and instructions can be found in the compressor selection programme and the section **Application Limits**.

The following parameters must be recorded and monitored during operation of the compressor:

Parameter	To be recorded	Purpose
Current for the driver	Upper limit value (Motor current limiter)	Protection of motor and compressor
Motor speed [1]	Motor speed	Adherence to the maximum and minimum permitted speeds
Position of control slide (primary slide)	MIN - position	Ensures unloaded start-up
	Entire adjustment length between MIN and MAX position of the slide	-For partial load regulation - For combined Vi partial load regulator [2]
Position variable control slide limitation (secondary slide) [3]	Entire adjustment length between Vi_{max} and Vi_{min}	Vi-adjustment
Suction pressure	Suction pressure within the measuring range to be specified	Controlled variable for capacity control and Vi adjustment
Compression discharge pressure	Upper limit value	Protection of compressor and plant components
	Discharge pressure within the measuring range to be specified [4]	Controlled variable for Vi-adjustment
Discharge temperature [4]	Upper limit value	Protection of compressor and plant components
Oil temperature upstream of compressor	Oil feed temperature for bearings and shaft seal within the measuring range to be specified	Protection of compressor
Compressor oil inlet pressure (after oil pump)	Differential pressure between oil pressure entering the compressor and compressor discharge pressure	Protection of compressor

[1] for speed-controlled drive motors.

[2] for compressors with Vi-adjustment.

[3] a position sensor for the variable control slide limitation (secondary slide) is installed as agreed.

[4] logging with low time constant transmitters k (k < 10 sec).

11 LUBRICATING OILS FOR SCREW COMPRESSORS

11.1 Approved oils

The currently valid list of oils approved by the manufacturer for screw compressors is available from the manufacturer.

11.2 HINTS FOR SELECTION OF REFRIGERATION OIL

The characteristics of refrigerating machine oil influence the functionality of a refrigerator with oil flooded screw compressors, since this cannot be precluded despite the high-capacity oil separator and remnants of refrigerating machine oil can enter the refrigerant line. So when selecting oil,

- a sufficient lubricity of the oil at the bearing points of the screw compressor (minimum oil viscosity with consideration of the solubility of refrigerants in oil depending on both the pressure and temperature),
- the vapour pressure of the oil for a proper separation behaviour in the oil separator,
- a sufficient fluidity of the oil at both the evaporating and suction temperature,
- the requirements upon the miscibility of the liquid phases of the refrigerant and the oil (miscibility gap).

need to be taken into account.

The refrigerant used, the operation conditions and the specific plant design all determine the required characteristics of the refrigeration oil.

At present, five different base oil brands are used:

1. **M, M*:** Mineral oils for ammonia and R22
2. **PAO:** Polyalphaolefins for ammonia and CO_2 (R744), R290, R1270.
3. **AB:** Alkyl benzene for ammonia and R22
4. **PAG:** Polyglycol (PAG-oil) for ammonia, natural gas and hydrocarbon compounds, R290, R1270.
5. **E:** Ester oil for R22, R404A, R134a, R507 and CO_2 as well as other refrigerant blends such as R410A and R407C

Besides the pure base oil other blends of mineral oil or alkyl benzene with polyalphaolefin can also be used.

The characteristics of the refrigerants regarding the oils mentioned are very different.

Thereby 2 fundamental requirements are needed from the refrigerant and refrigeration oil:

- Minimum oil viscosity of 7 cSt, maximum 70 cSt, at the compressor inlet with consideration for the refrigerant solubility in oil
  - For frame sizes XG, XH a minimum oil viscosity of 15 cSt at the compressor inlet with consideration for the refrigerant solubility in oil

and

- Miscibility of both liquid phases of a certain portion of the oil (ab. 1 to 2 %) and the refrigerant.

In addition to the lubrication oil viscosity requirements the discharge temperatures in the compressor need to be high enough so that oil containing refrigerants can be cooled by at least 5 K, so that no foam forms in the compressor in the event of lower temperatures and/or temperature increases before the oil reaches the storage locations.

The second basic requirement is not fulfilled by mineral oil, alkyl benzine polyalphaolefin in association with ammonia, since there is a 100% mixture gap and neither the solubility of the refrigerant vapour in the oil nor miscibility in the liquid phases. Nevertheless these oils are used NH_3 plants. Fine oil separation phases prevent larger oil volumes from entering the refrigeration circuit.

The base oil versions mentioned will bring about differing oil carry-over rates as the flash points of the oils cited differ greatly from each other (lowest flash point of alkyl benzene at approx. 160 °C, highest flash point of polyalphaolefin considerably above 200 °C).

Although the fluidity of the oil is characterized by the pour point indicated by the oil manufacturers, the basic oil types named above have varying VT characteristics so that even with equivalent initial viscosities such as 68 cST viscosity differences may occur at lower temperatures in the evaporator, which at -20°C vary between 1500 and 20000 cSt.

With relation to oils, the refrigerants feature the following properties:

- ***Ammonia***

  Ammonia is slightly soluble with lubricants. The mechanical mixture is very intense so that oil is always carried with the ammonia. Due to the low share of ammonia, the lubrication of the oil will not change and the miscibility of oil and refrigerant during the liquid phases is not possible. Efficient oil separation is thus necessary.

- ***HFC (e.g. R134a, R404A, R507)***

  HFC contains no chlorine and is not limited in its applications. Ester oil is used for this refrigerant. The greater solubility of this refrigerant in ester oil needs to be taken into account when selecting an oil, since the initial viscosity of the oil through the dissolving of refrigerant in the oil can change significantly. However, the fluidity of the oil in the evaporator is given due to proper miscibility over a wide range.

The most important properties of the main oil groups are described in the following:

1. ***Mineral oil***

   Naphten-based mineral oils are best suited for refrigerating plants, but paraffin-based oils are also used. Special treatment (paraffin removal) means that paraffin-based oils have more or less the same characteristics as naphten-based oils. Mineral oils are characterised by relatively low miscibility with HCFCs (e. g. R22) at lower temperatures. Mineral oils have a relatively high viscosity index and low steam pressure (high flammability) that positively influences the oil impact.

2. ***Alkyl benzene (also known as alkyl benzole)***

   Alkyl benzenes are synthetic oils created from natural gas. They are characterized by high miscibility with HCFC's (e.g. R22) even at lower evaporating temperatures. Alkyl benzenes have greater thermal stability than mineral oils (ammonia use in piston compressors). However they have a higher tendency towards foam formation than mineral oils in the oil separator and thus to greater discharge despite the lower flame point. When switching from mineral oil to alkyl benzenes, it should be noted that alkyl benzenes have higher cleaning efficiency and thus the filter will dirty faster after the oil change.

3. ***Polyalphaolefin***

   Polyalphaolefins are synthetic oils with high levels of chemical and thermal stability. They are thus preferred for use in compressors with high discharge temperatures e. g. in heat pumps Polyalphaolefins are also used in ammonia plants. The very low pour point creates a very low evaporating temperature. The high flame point leads to low oil discharge.

4. ***Ester oils***

   As opposed to mineral oils, alkyl benzines and polyalphaolefins, ester oils are soluble in the new non-chlorinated HFC's (R134a, R404A, R507 etc.) So ester oils are thus the only lubricant that may be used with HFCs. Ester oils have a high flash point, whereby the oil vapour share in the oil separator and thus the oil discharge are positively influenced. Ester oils are hygroscopic. They absorb water when they come into contact with the atmosphere. Ester oils thus need to be stored in sealed containers. The compressors needs to be thoroughly evacuated before the oil filling.

5. ***Polyglycol oil***

   Polygylcol oils are soluble in ammonia and very hygroscopic. They are thus subject to the same handling conditions as ester oils. When selecting oils the drop in viscosity resulting from dissolving refrigerants in the oil needs to be taken into consideration. The flowablility of the oil in the evaporator needs to be tested taking into account the miscibility between the refrigerating machine oil and the refrigerant at each relevant evaporating temperature.

PARAMETERS USED FOR OILS:

Specific density

The density difference between the coolant and oil may be important for the oil return. Care should be taken that alkyl benzine has a lower density than mineral oils and polyglycol and greater density than mineral oil. The methods for measuring density is described in DIN 51757.

Viscosity

In accordance with the ISO 3448 standard lubricants are classified according to viscosity classes listed as ISO VG No . The ISO No. is only a nominal value in such classes, i. e. the actual viscosity may deviate in certain areas (DIN 51562). The viscosity entries are based on the temperatures of 40°C and 100°C.

Viscosity index

The viscosity index supplies the connection between the change in viscosity depending on the temperature (ISO 2909). Greater viscosity index readings mean lower viscosity changes when temperatures change compared to lower viscosity index values.

Flash point

The flash point indicates at which temperature the vapours escaping from a heated cup may be ignited over a flame. The measuring method is described in ISO 2592. Oils with higher flash points have lower oil vapour pressures. This will enhance the possibilities of oil separation from a compressed gas in the oil separator and reduce the oil carry-over rate from the compressor into the plant.

Pourpoint

The pour point is the temperature, where the flowability of oil declines so that that under certain conditions no oil will flow from a container within five seconds. In accordance with the standards, the pourpoint temperature is 3% lower than the measured temperature (measuring method in accordance with ISO 3016) The pour point is interesting for material pairs that are not soluble with one another. Oils with a low pourpoint are easier to lead back to the suction side than oils with higher pour points. Practice teaches that it is possible to use oils at evaporating temperatures lower than the pourpoint without having any operational problems.

Floc point

The floc point is the temperature where R12 liquids with a 10% oil admixture will become darkened due to wax particles separating from the oil when the liquid is cooled (measuring method in accordance with DIN 51351). The floc point is interesting when oils and refrigerants are mixed together. The floc point displays that an oil has fewer wax components and plants with HCFC (e. g. R22) can be operated at lower evaporating temperatures. Wax from oil can lead to problems on the expansion valves or on regulating valves. A critical solution temperature shall be supplied for ester oils using a mixture of 10% oil and 90% R134a. The critical solution temperature is that which the oil is completely removed from the refrigerant (no standardized amount).

Aniline point
The aniline point indicates the temperature at which a homogeneous solution will clear when warmed with a constant volume share of a lubricant or lubrication material or oil and aniline when cooling and clouding occurs through separation upon cooling. The aniline point is the measurement of unsaturated carbon which can be found in the oil. It is also the measurement of various sealing materials the oil comes into contact with (measuring method in accordance with ISO 3977). Most refrigerating machine oils have a low aniline point. Neoprene or chloroprene o-rings swell and therefore need to be replaced after disassembly.

Neutralization number
The neutralization number displays the acidic value of an oil and is generated using titration with caustic soda (KOH). The value is provided in mg KOH per g oil (measurement method in accordance with DIN 51558). Fresh oil should have low neutralization number.

Notice

Hints for oil change

► When changing the oil type or the manufacturer of an oil, consult the seal manufacturer beforehand to prevent any problems in operating the plant.
► If the oils are not compatible excretions from the oil are possible which may lead to problems with the plant (oil filter, lubricating capacity of the bearings, oil return not assured).
► Should it still be necessary to use another type of oil it is absolutely imperative that all oil be removed from the plant and compressor and oil separator be thoroughly cleaned (when possible with additional rinse cycle).

Notice

Validity of the oil selection tables

► All oils permitted for use in Grasso screw compressors are listed in the oil selection tables. Depending on the specifications of the plant the technical characteristics listed above need to be taken into consideration when making the oil selection.

12 Regulation on the Storage of Compressors

12.1 Regulation on the Storage of Compressors with Standard shaft seal

The compressor must be stored on a suitable level transport pallet and in the same position as in operation (feet downwards) before mounting on a compressor package.

The compressor is delivered without oil fill.

On delivery, the compressor is sealed and filled with dry nitrogen by the manufacturer (0.5 bar gauge pressure, moisture content <300 ppm).

Notice

General regulations for the storage of compressors.

► All regulations listed below must be observed.
► Failure to comply with the regulations will void the warranty.

Regulation on Storage of the Compressor before Putting into Service:

- The compressor must be stored in a dry place.
- Turn the coupling /drive shaft of the compressor by four to five of a shaft turn every four weeks.
- If stored for longer than 16 weeks:
  - The factory nitrogen fill is to be checked at 16 week intervals, documented and if necessary topped up (0.5 bar gauge pressure, moisture content <300 ppm).
  - If the compressor has been opened in the meantime, and if further lengthy separate storage is planned, the compressor must be filled with dry nitrogen (0.5 bar gauge pressure, moisture content <300 ppm).
  - In the event of lengthy stoppages there is a risk of the shaft seal sticking onto the shaft. At start-up, this can lead to damage to the shaft seal. Because of this, prior to start-up of the compressor **removal and cleaning of the shaft seal** is mandatory in order to ensure that its functions **correctly**:
    - Use two pressure screws to remove the cover of the shaft seal, including the stationary gasket inserted in it.
    - Remove the seal package on the shaft together with the corresponding seal ring by hand or using a removal device. If the seat is loose, the seal package may stick to the stationary seal ring and be pulled out when the cover is removed.
    - Clean and lightly grease the shaft seating of the shaft seal **with a lint-free cloth**.
    - Push the seal package onto the shaft.
    - Press the seal package together against the spring force and check whether the sealing ring automatically expands.
    - Fit the cover of the shaft seal.
- In the event of a stoppage lasting longer than 6 months before putting the compressor into service, check the shaft seal by dismounting it like described before. Replace the O-rings of the shaft seal.

Regulations for longer downtimes after commissioning:

The following is specified if the compressor is taken out of service for a lengthy period (longer than one week):

- Close the shut-off valves on the suction and the discharge side of the screw-compressor unit.
- Turn the coupling of the compressor by four to five of a shaft turn every 4 weeks.

12.2 Regulation on the Storage of Compressors with Dual shaft seal

The compressor must be stored on a suitable level transport pallet and in the same position as in operation (feet downwards) before mounting on a compressor package.

The compressor is delivered without oil fill.

On delivery, the compressor is sealed and filled with dry nitrogen by the manufacturer (0.5 bar gauge pressure, moisture content <300 ppm).

Notice

General regulations for the storage of compressors.

► All regulations listed below must be observed.
► Failure to comply with the regulations will void the warranty.

Regulation on storage of the Compressor before putting into Service:

- The compressor must be stored in a dry place.
- Turn the coupling /drive shaft of the compressor by four to five of a shaft turn every four weeks.
- If stored for longer than 16 weeks:
  - The factory nitrogen fill is to be checked at 16 week intervals, documented and if necessary topped up (0.5 bar gauge pressure, moisture content <300 ppm).
  - If the compressor has been opened in the meantime, and if further lengthy separate storage is planned, the compressor must be filled with dry nitrogen (0.5 bar gauge pressure, moisture content <300 ppm).
- In the event of a stoppage lasting longer than 6 months before putting the compressor into service, a vacuum test and a leakage test has to be done according to the installation instruction of the compressor. Here also the sealing oil chamber of the dual shaft seal has to be included.

Notice

Important note for the leak test.

► Observe the rules and instructions of the operating manual of the shaft seal.

4.1 Pressurise the compressor.

4.2 Pressurise the sealing oil circuit, max. 1 bar gauge pressure.

► The pressure in the sealing oil circuit must be always less than the pressure inside the compressor. This is also has to be observed at the completion of the leakage test.

Regulations on lengthy stoppages after putting into Service:

The following is specified if the compressor is taken out of service for a lengthy period (longer than one week):

- Close the shut-off valves on the suction and the discharge side of the screw-compressor unit.
- Turn the coupling of the compressor by four to five of a shaft turn every 4 weeks.

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